DICE:

USER'S MANUAL

TABLE OF CONTENTS

1. WHAT IS DICE

1.1. Introduction

A relational database containing information extracted from the *International Criticality Safety Benchmark Evaluation Project (ICSBEP) Handbook* has been developed with a user interface that allows interrogation of the database. The database was first released with the 2001 Edition of the *ICSBEP Handbook*. The database and the corresponding user interface are referred to as DICE (**D**atabase for the **I**nternational Handbook of Evaluated **C**riticality Safety Benchmark **E**xperiments). DICE is maintained and upgraded on a continual basis and released annually with the *Handbook*. DICE allows simple or complex queries or searches on specific data and parameters of experimental benchmarks within the *ICSBEP Handbook*. A wide variety of searches can be performed, such as experiments performed at a specific facility or experiments matching select engineering parameters, e.g., the main components of a fuel-pin cell (type of fuel, cladding, moderator, and/or coolant). Additionally, global searches of all the experimental configurations containing any nuclide or isotope of interest can be performed using queries such as "Fuel region contains" and "Neutron Balance."

A very brief overview of DICE follows. A more complete description of the content and how to perform queries is provided in the Glossary (Section 11). It is a glossary containing all the terms used by DICE.[1] It provides the definition of each term and indicates where in the *ICSBEP Handbook* the data are obtained. This glossary is intended to assist the users of DICE not only with searches of the database but also with their interpretation of the parameters obtained by those searches. Furthermore, the clarification of the terms used by DICE will also assist benchmark evaluators, who are now required to enter select benchmark data into an Excel spreadsheet from which it will be automatically entered in the DICE database.

Refinements and additions in both the content and search capabilities of the DICE database are ongoing. Comments, corrections and suggestions are always welcome and can be forwarded to dice@oecd-nea.org.

1.2. What's new?

New features have been added in the DICE 2014 edition database tool:

- In the correlation matrix tab, a sensitivity matrix has been added which contains the cosine similarities of sensitivity vectors of cases;
- New plot type, parallel axis plot;
- Rank Similar pane has be taken from IDAT;
- Improved interface for importing personal k_{eff} values;
- Tree structure in searches for sensitivities.

The database content has also been revised and approved evaluations in 2014 have been incorporated as well as new spectra calculation results. New sensitivity data files generated by the NEA have also been included.

[1] The Glossary only addresses the terms contained in the Critical / Subcritical Search pane of DICE.

2. QUICK START

In order to use the DICE tool and access the DICE database, you must:

- Have the DVD containing DICE in order to run DICE directly from the DVD or add DICE to your computer as instructed below;
- Have Java 6, 7 or 8 installed on your computer or add it as instructed below;
- Have a large screen; a minimum resolution of 1024×768 is recommended.

2.1. DICE 2014 DVD Contents

The DVD contains the following directories and files for DICE installation and operation, as well as the "`DiceData`" folder that contains the calculated data:

- Root directory contains this user's manual;
- Directory "`CD2014`": contains the *ICSBEP Handbook*;
- Directory "`Dice`": contains `dice.bat` and `dice.sh` batch command files;
- Directory "`DiceData\balance`": contains neutron balance files;
- Directory "`DiceData\nea`": contains NEA sensitivity files and corresponding input files for SCALE 6.0, 6.2beta and MCNP6;
- Directory "`DiceData\newE`": contains energy group structure files;
- Directory "`DiceData\ornl`": contains ORNL TSUNAMI-3D-K5 and TSUNAMI-3D-K6 sensitivity profiles and corresponding input files for KENO V.a and KENO VI;
- Directory "`DiceData\sensitivity`": contains IPPE sensitivity files;
- Directory "`DiceData\spectra`": contains spectra files;
- Directory "`Dice\databases`": contains the H2 local database;
- Directory "`Dice\software`": contains the DICE software;
- Directory "`Dice\plugins`": contains DICE plugins (e.g. ORNL VIBE tool).

2.2. DICE Installation (Optional)

You can run DICE directly from the DVD or copy the entire "`Dice`" folder contents onto your hard drive. This requires approximately 87 MB. The "`DiceData`" folder is 4.53 GB and can be copied as well or its content can be accessed from the DVD.

2.3. Java Installation

If Java 6, 7 or 8 is already installed on your system, skip Section 2.3 and proceed to Section 2.4. Java can be downloaded on Oracle' websites: http://www.java.com/ or http://www.oracle.com/technetwork/java/javase/downloads/index.html.

Note: Java for Mac OS X users is provided by Apple.

2.4. Launch DICE

DICE can be launched by using the `dice.bat` (for Windows) or `dice.sh` (for Linux/UNIX) executable scripts available in the "`Dice`" folder. For Macintosh users, the folder `mac_os_x` contains a Mac OS X bundle.

However, if you wish to use VIBE as a DICE plugin, use these executable scripts instead: `vibe-dice.bat` (for Windows) or `vibe-dice.sh` (for Linux/UNIX).

Once you launch DICE, a Disclaimer window will appear before the main DICE window appears.

Note: Plugins currently share the connection to the same "LocalShared" database. This database is the H2 database provided on the DVD which must be copied on a local hard drive (The database management system needs to create files to share the connection between DICE and any plugin).

3. GENERAL OVERVIEW

The first screen of the user interface is the "Search" window, which is shown in Figure 1.

The DICE main window is composed of six main panes:

1. Critical / Subcritical: searches through all of the critical and/or subcritical experiment cases (Volumes I-VII) of the *Handbook*;

2. Alarm / Shielding: searches through all of the alarm and/or shielding measurement cases (Volume VIII) of the *Handbook*;

3. Fundamental Physics: searches through all of the fundamental physics measurement cases (Volume IX) of the *Handbook*;

4. Correlation Matrix: displays correlation coefficients for criticality evaluations;

5. Rank Similar: compute distances between user input and database content;

6. k_{eff} trend plots: displays averaged C/E values, by various categories.

As noted, only terms in the Critical / Subcritical pane are presently discussed in the Glossary.

The "File" menu allows you to:

- Export DICE results tables/plots into files;
- Open a file from the ICSBEP Handbook (evaluation PDF, spectra PDF or balance file);
- Open the Settings dialog;
- Check if an update is available (requires an Internet connection);
- Exit the software.

The "Database" menu allows you to switch databases:

- "Local": the local database provided on the DVD;
- "LocalShared": the local database, ready to be shared with DICE plugins;
- "NEA": the NEA master database that can be updated after the DVD has been released.

The database menu is dynamically updated to display the selected database name.

The "Personal_Keff" menu allows you input your own k_{eff} calculation values:

- "Load values": Add user k_{eff} calculations to a local copy of the database. Only useable if DICE is copied from the DVD onto a local computer. For the user to load their own data, the following information is required: Evaluation Id, Case Id, Benchmark Model, Code, Library, Calculated Keff, Calculated Keff uncertainty. An example is shown below.
  `PU-MET-FAST-042, 001, Simplified Model, KENO, ENDF/B-VI.8 Continuous, 1.01282, 0.00010`

- "Export values to file": export all previously loaded calculation values to a tab separated file;
- "Clear values": reset database content by removing all previously loaded personal values.

Note: To successfully update DICE, DICE needs to be copied on a local folder in order to create new files containing updates.

The "Window" menu allows you to 'clone' a DICE window.

3.1. Critical / Subcritical Pane

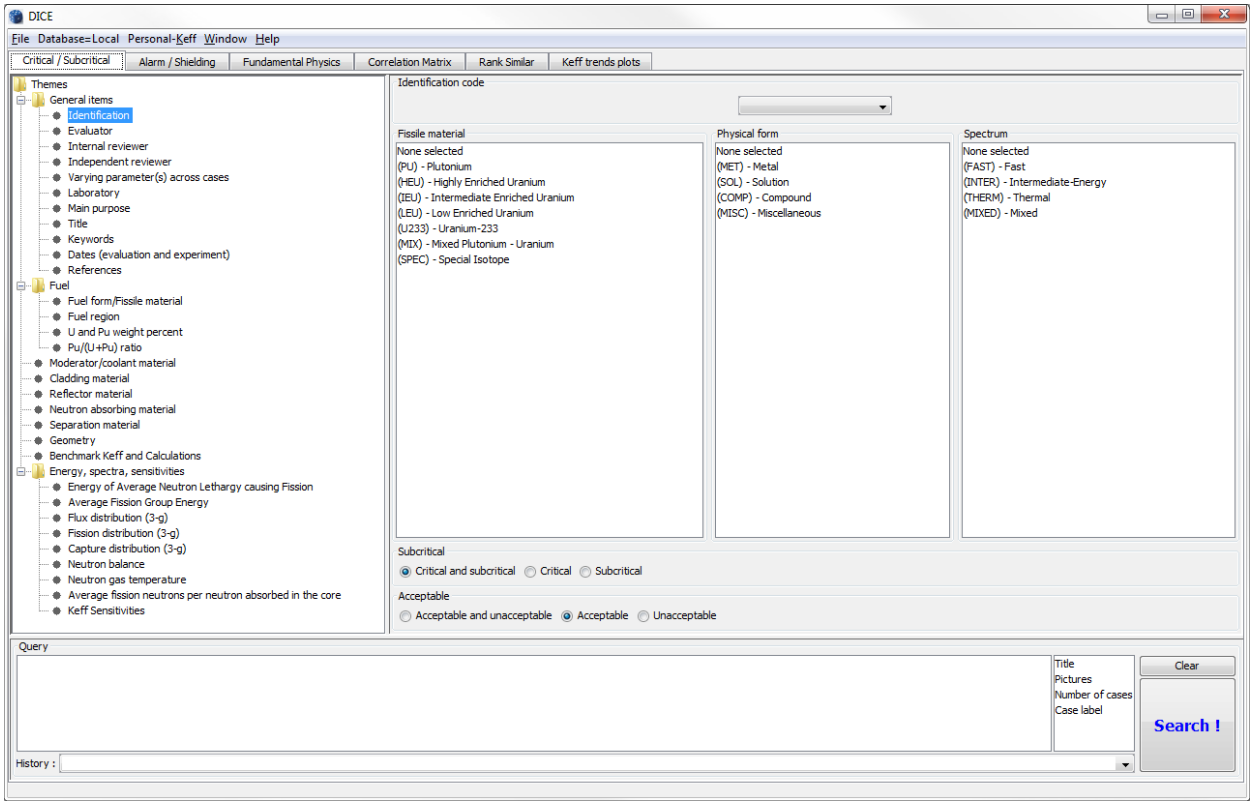


Figure 1: Critical / Subcritical Pane.

This pane provides you with various data and/or parameter search criteria (e.g. fissile material, evaluator, geometry, etc.) allowing you to search for specific critical and/or subcritical cases in regards to your search criteria (Volumes I,II,III,IV,V,VI and VII of the *ICSBEP Handbook*). The search criteria are explained in detail in the Glossary.

3.2. Alarm / Shielding Pane

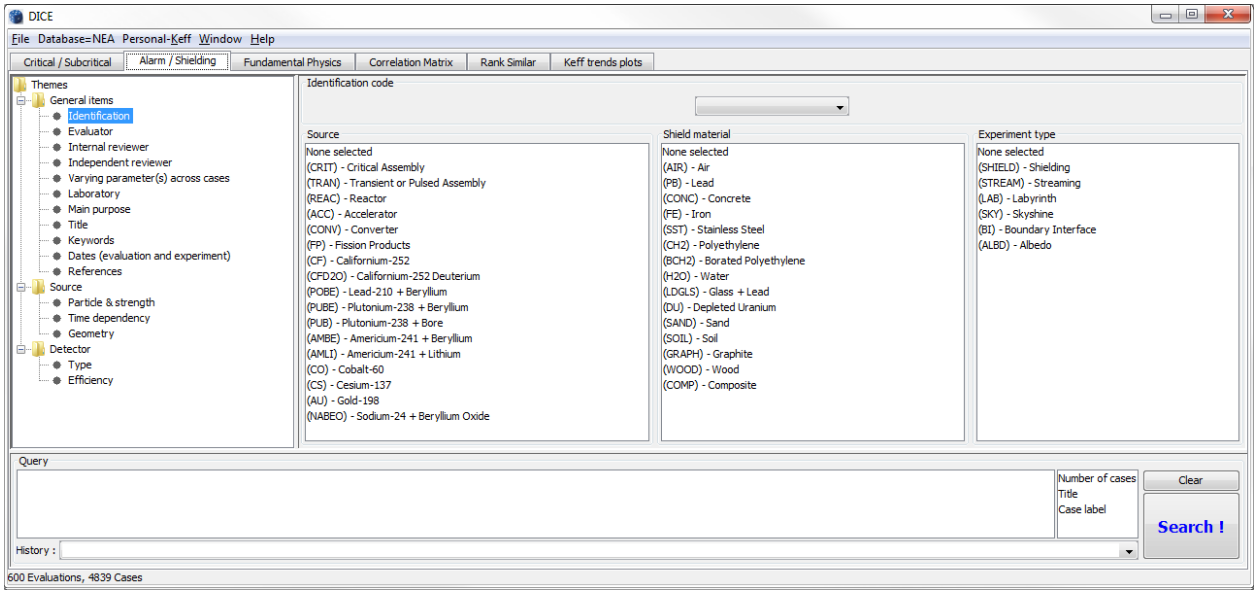


Figure **2**. Alarm / Shielding Pane.

This pane provides you with various data and/or parameter search criteria (e.g. source, evaluator, detector type, etc.) allowing you to search for specific alarm and/or shielding cases in regards to your search criteria (Volume VIII of the *ICSBEP Handbook*). (As noted, only terms in the Critical / Subcritical pane are presently discussed in the Glossary.)

3.3. Fundamental Physics Pane

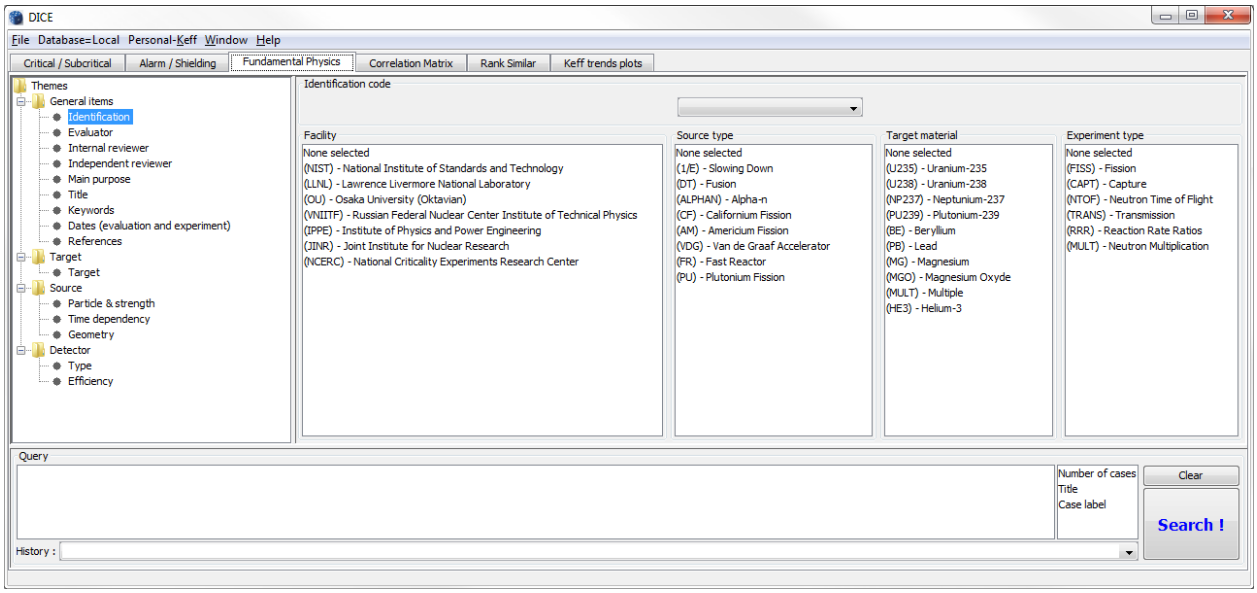


Figure **3**. Fundamental Physics Pane.

This pane provides you with various data and/or parameter search criteria (e.g. source, evaluator, detector type, etc.) allowing you to search for fundamental physics cases in regards to your search

criteria (Volume IX of the *ICSBEP Handbook*). (As noted, only terms in the Critical / Subcritical pane are presently discussed in the Glossary.)

3.4. Correlation Matrix Pane

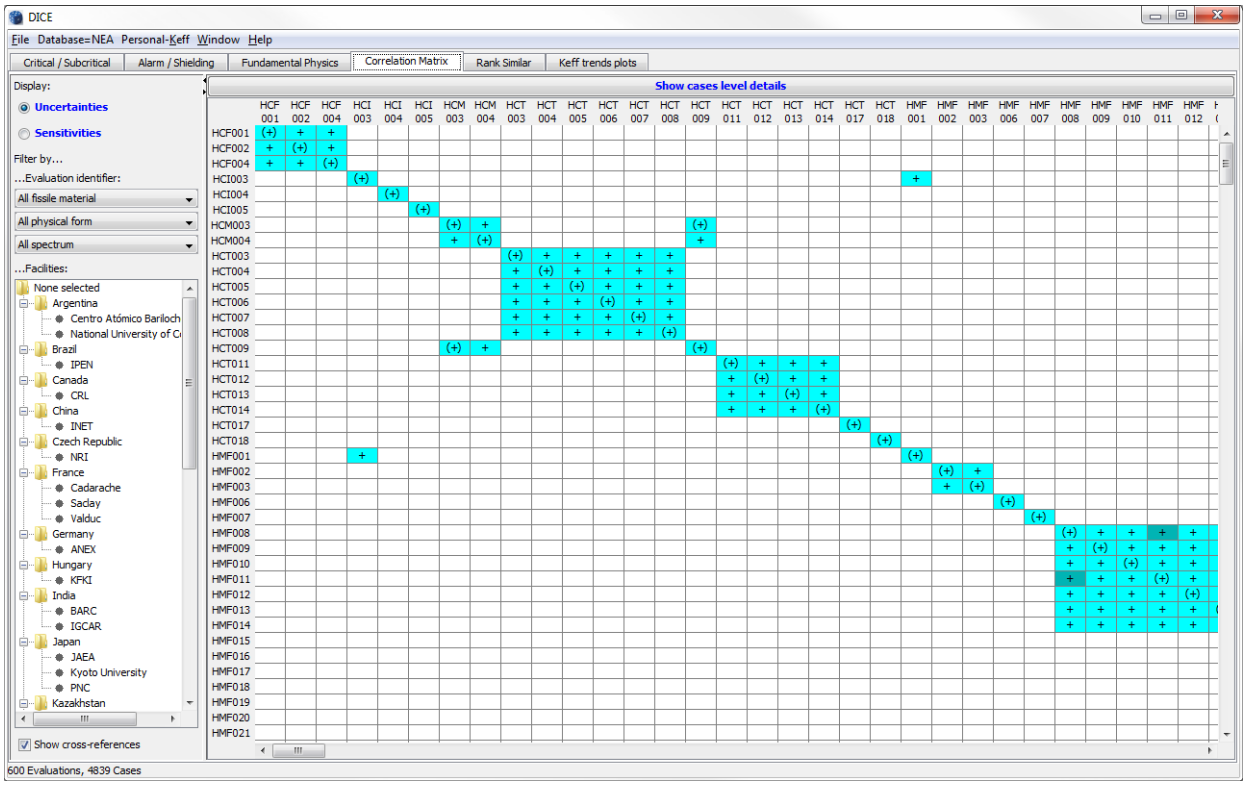


Figure 4. Correlation Matrix Pane.

This pane provides you with data indicating if the uncertainty in two criticality cases are correlated and to which degree (coefficient between 0 and 1000) or if the nuclear data sensitivity vectors are correlated (between -1000 and 1000); the correlation displayed depends if 'Uncertainties' or 'Sensitivities' is selected A pop-up displays the unscaled value, when the cursor hovers over the value.

Note: Only limited correlation coefficient data of uncertainties are currently available. These data were derived from IPPE and from ANL for the ZPR/ZPPR values.

3.5. Rank Similar Pane

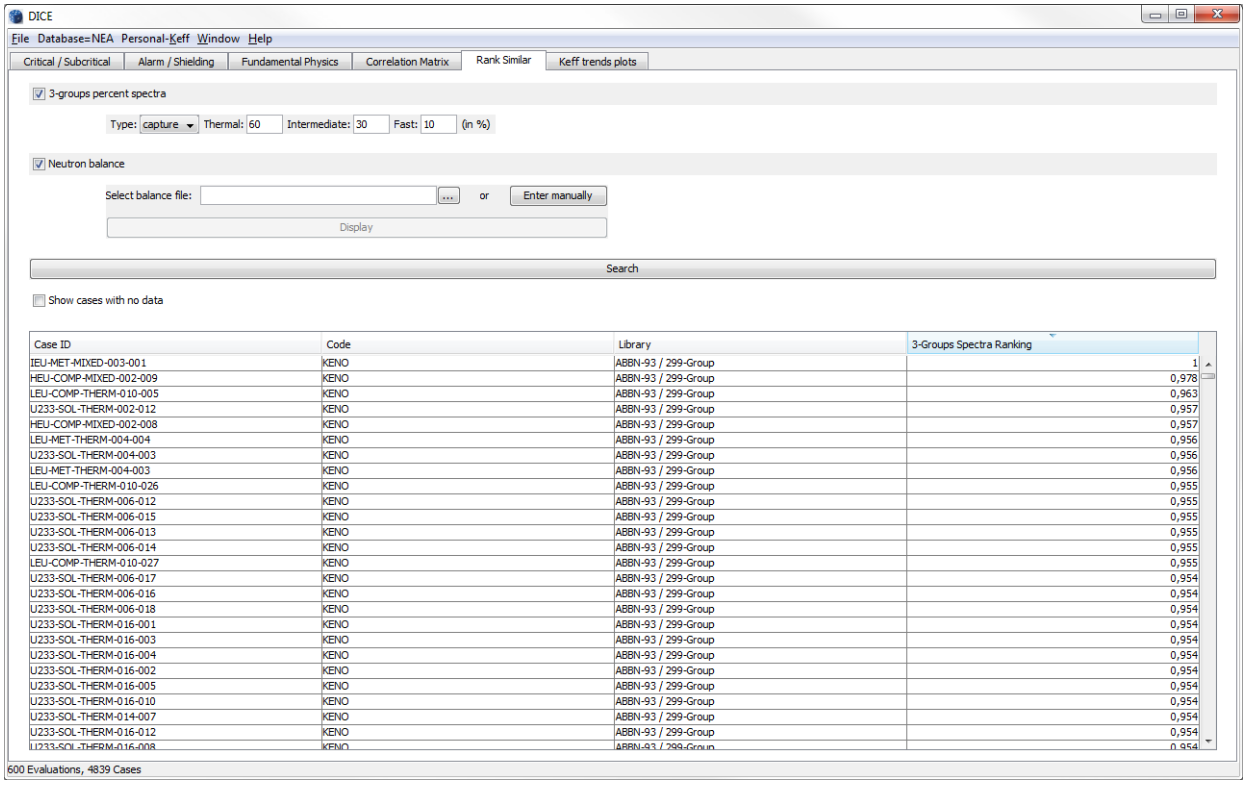
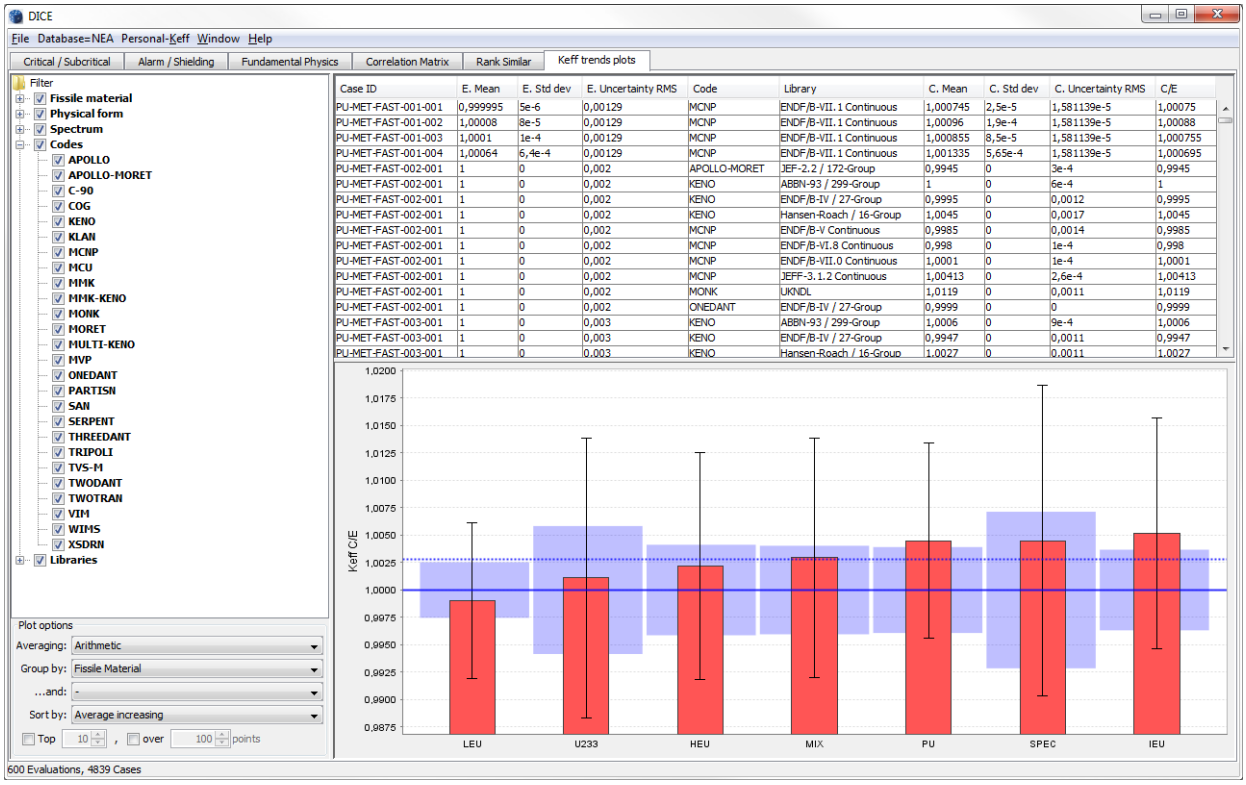


Figure 5. Rank Similar Pane

The Rank Similar pane allows users to rank benchmarks based on 3 group fluxes and neutron balance data.

See Section 3.5 for a description of this feature.

3.6. k_{eff} trend plots Pane



Case ID	E. Mean	E. Std dev	E. Uncertainty RMS	Code	Library	C. Mean	C. Std dev	C. Uncertainty RMS	C/E
PU-MET-FAST-001-001	0,999995	5e-6	0,00129	MCNP	ENDF/B-VII.1 Continuous	1,000745	2,5e-5	1,581139e-5	1,00075
PU-MET-FAST-001-002	1,00008	8e-5	0,00129	MCNP	ENDF/B-VII.1 Continuous	1,00096	1,9e-4	1,581139e-5	1,00088
PU-MET-FAST-001-003	1,0001	1e-4	0,00129	MCNP	ENDF/B-VII.1 Continuous	1,000855	8,5e-5	1,581139e-5	1,000755
PU-MET-FAST-001-004	1,00064	6,4e-4	0,00129	MCNP	ENDF/B-VII.1 Continuous	1,001335	5,65e-4	1,581139e-5	1,000695
PU-MET-FAST-002-001	1	0	0,002	APOLLO-MORET	JEF-2.2 / 172-Group	0,9945	0	3e-4	0,9945
PU-MET-FAST-002-001	1	0	0,002	KENO	ABBN-93 / 299-Group	1	0	6e-4	1
PU-MET-FAST-002-001	1	0	0,002	KENO	ENDF/B-IV / 27-Group	0,9995	0	0,0012	0,9995
PU-MET-FAST-002-001	1	0	0,002	KENO	Hansen-Roach / 16-Group	1,0045	0	0,0017	1,0045
PU-MET-FAST-002-001	1	0	0,002	MCNP	ENDF/B-V Continuous	0,9985	0	0,0014	0,9985
PU-MET-FAST-002-001	1	0	0,002	MCNP	ENDF/B-VI.8 Continuous	0,998	0	1e-4	0,998
PU-MET-FAST-002-001	1	0	0,002	MCNP	ENDF/B-VII.0 Continuous	1,0001	0	1e-4	1,0001
PU-MET-FAST-002-001	1	0	0,002	MCNP	JEFF-3.1.2 Continuous	1,00413	0	2,6e-4	1,00413
PU-MET-FAST-002-001	1	0	0,002	MONK	UKNDL	1,0119	0	0,0011	1,0119
PU-MET-FAST-002-001	1	0	0,002	ONEDANT	ENDF/B-IV / 27-Group	0,9999	0	0	0,9999
PU-MET-FAST-003-001	1	0	0,003	KENO	ABBN-93 / 299-Group	1,0006	0	9e-4	1,0006
PU-MET-FAST-003-001	1	0	0,003	KENO	ENDF/B-IV / 27-Group	0,9947	0	0,0011	0,9947
PU-MET-FAST-003-001	1	0	0,003	KENO	Hansen-Roach / 16-Group	1,0027	0	0,0011	1,0027

Figure 6. k_{eff} trend plots Pane.

This pane gives an overview of the trends in C/E within the database for a particular measurement. The intent is to allow the user to see the overall information content in the database and apply user friendly filters to 'drill down' to a particular data set.

See Section 3.6 for a description of this feature.

3.7. Customizing DICE

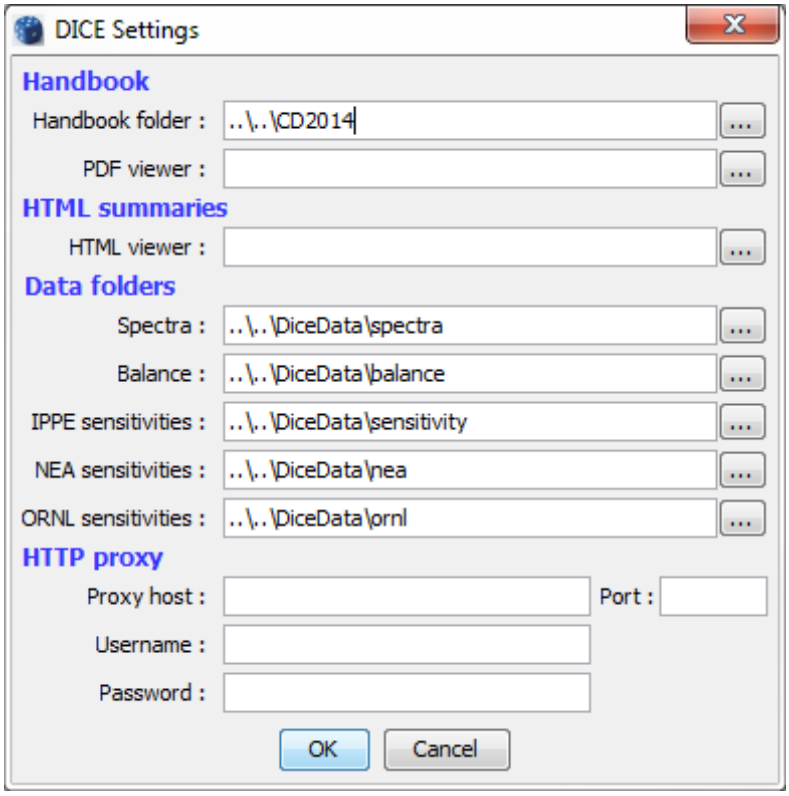


Figure 7. Settings Dialog

Once the DICE DVD is inserted or DICE is available on your computer, Java is installed and available, and DICE is launched, you may be required to customize DICE to operate properly on your computer. This can be done by opening the Settings dialog by selecting the menu "File > Settings…".

This dialog allows you to set:

- The ICSBEP Handbook folder location;
- The PDF viewer executable file to use;
- The HTML viewer executable file to use;
- The location of the folders for balance, spectra, and sensitivity data files; you must restart DICE for this setting to take effect;
- HTTP Proxy information (host, port, and credentials); you must restart DICE for this setting to take effect.

Note: If you run DICE on Microsoft Windows, the PDF and HTML viewer settings should not need to be set. When these settings are left empty, DICE will launch your default PDF and HTML viewers.

Note: DICE settings are stored in a plain text file located under your personal documents folder (`%USERPROFILE%` under Windows); named `dice_2_5_settings.txt`. To reset the settings to the default values you can delete this file while DICE is not running.

3.8. About DICE Dialog

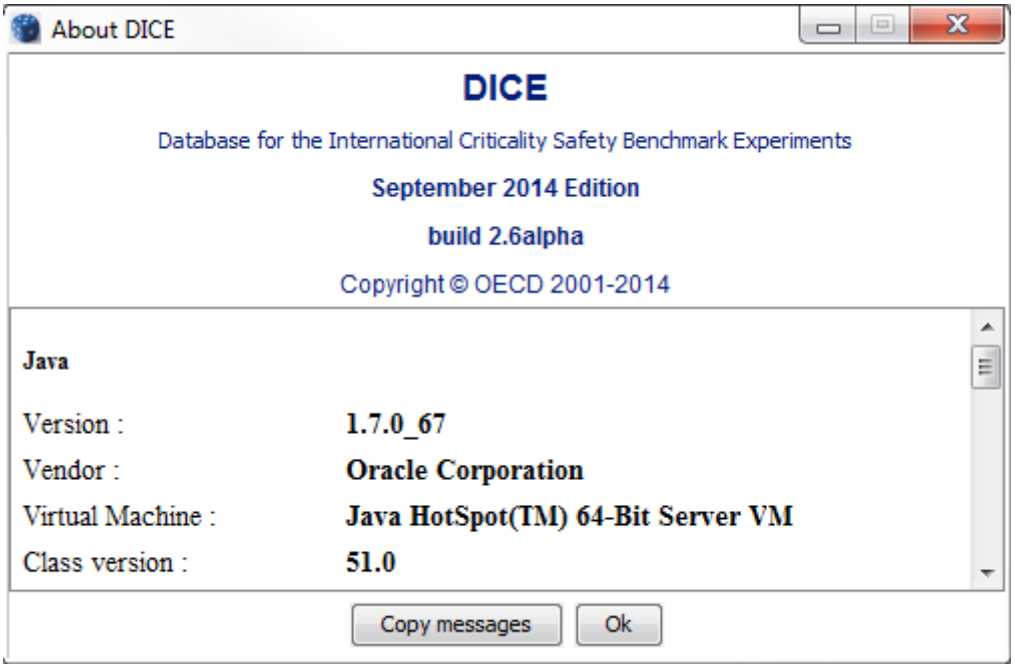


Figure 8. About DICE dialog.

If you would like to view this information, open the About DICE dialog by selecting the menu "Help > About DICE".

This dialog shows summary information about the DICE version, Java version, operating system, and network settings that you are currently using. This information should be transmitted to the DICE developers if you report a problem or submit an enhancement request (use the "Copy messages" button to copy this information to the clipboard). To contact DICE developers you can also send an e-mail to dice@oecd-nea.org.

4. SEARCHING

DICE allows you to search the *Handbook* for particular evaluations. The three panes "Critical / Subcritical", "Alarm / Shielding" and "Fundamental Physics" work the same way.

4.1. Setting Search Criterion

The list or tree in the far left side of the main window presents the available search criteria grouped into "Themes.". The right panel(s) of the window displays the selected theme control panel(s). The four main types of search criterion are described below.

4.1.1. Selection List

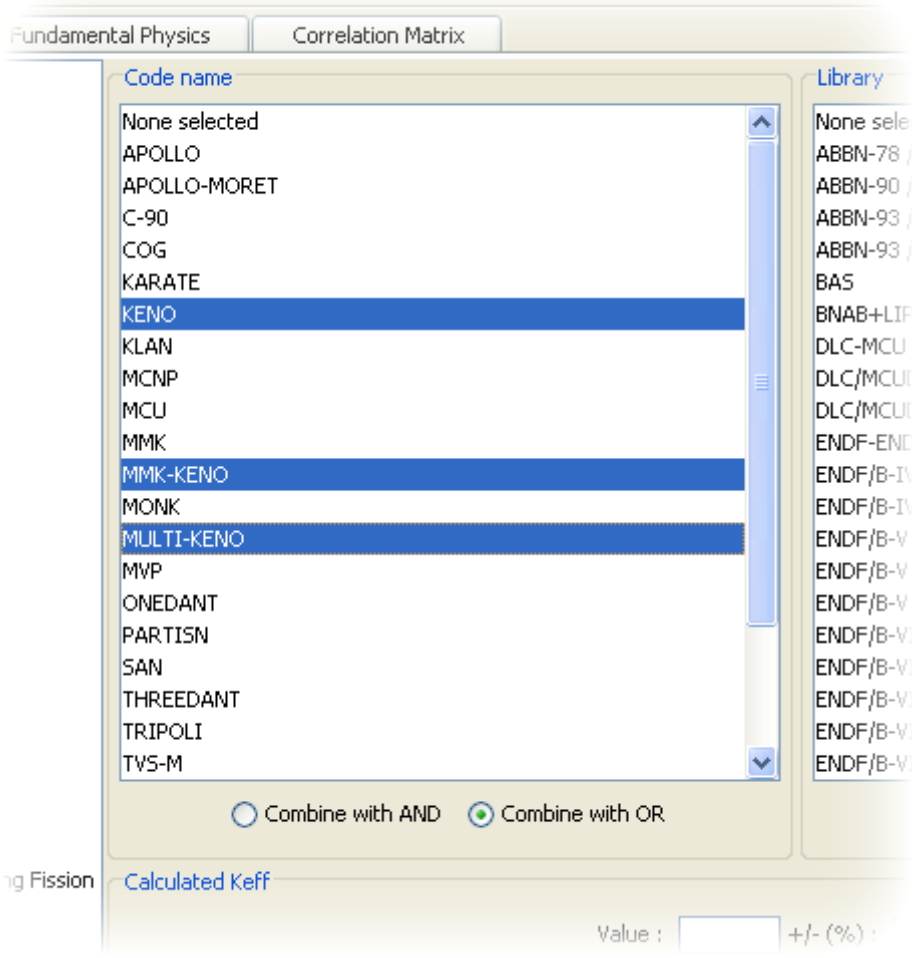


Figure 9. Selection List criterion.

Select one or more items from the list.

Note: You can use the CTRL or SHIFT keys to select multiple items.

The first item, "None selected", can be used to unselect all highlighted items.

Some theme criteria can have multiple values for a given ICSBEP evaluation or cases within an evaluation (e.g. moderator material). In these instances, you can search evaluations by selecting:

- Any of your choices with the "OR" button;
- Or all of your choices together with the "AND" button.

These two buttons remain grayed-out until you select more than one item from the list ("OR" is the default).

For example, by selecting "Lucite" and "Water (Light Water)" in the moderator/coolant materials list and leaving the default "OR" button, you will find the ICSBEP evaluation cases having "Lucite" or "Water (Light Water)" or both as moderator/coolant material. If you select the "AND" button, you will only find those evaluation cases that have "Lucite" and "Water (Light Water)".

4.1.2. Numerical Values

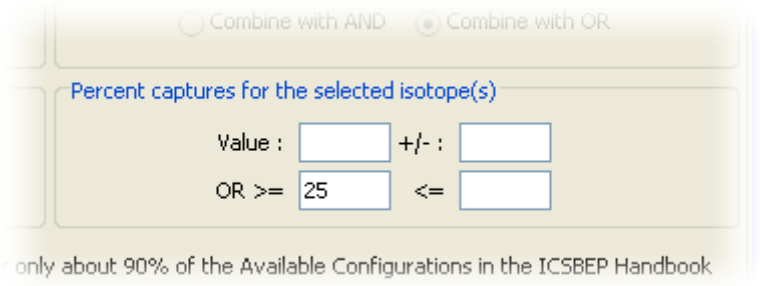


Figure 10. Numerical Values criterion.

You can search for numerical values in two ways:

- For a specific value with an optional accuracy, the accuracy has to be input as a percentage of the specified value (e.g. "75" with an accuracy of "10" would search for values between 68.5 and 82.5).
- For a range of values, specify a minimum and/or a maximum value. If you specify an upper value that is less than the current value, the criterion is not set.

You can enter a numeric value in scientific notation (e.g. 1E3 means 1000).

Note: If a numeric value is invalid, it is displayed in white on a red background (e.g. you cannot add a percent sign [%] in the accuracy field).

4.1.3. Text Fields

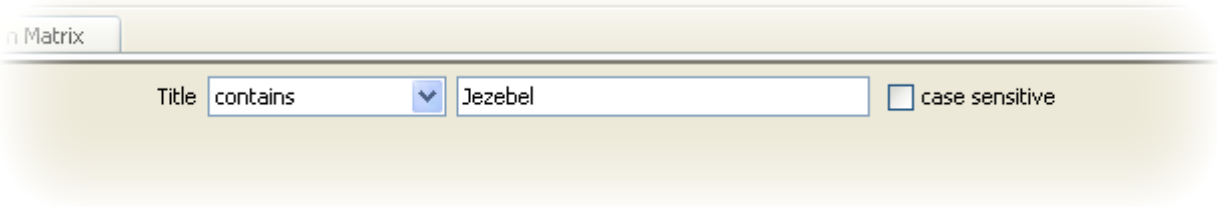


Figure 11. Text criterion.

Text searches may be performed by selecting “Title”, “Keyword”, or “Reference” under the General Items tree structure. Keyword searches are limited to the list of Keywords provided in each ICSBEP evaluation report. To search on text, first choose the operator in the drop-down:

- Contains;
- Does not contain;
- Begins;
- Does not begin;
- Ends;
- Does not end;
- Equals;
- Does not equal.

Then, enter a word or part of a sentence in the text field. This criterion also supports a wildcard character (‘%’).

If you wish to perform a case sensitive search, check the “case sensitive” box.

Note: You can search for Unicode characters as they appear in titles and references (e.g. some Russian references are spelled in Cyrillic in the database).

4.1.4. Hierarchical Field

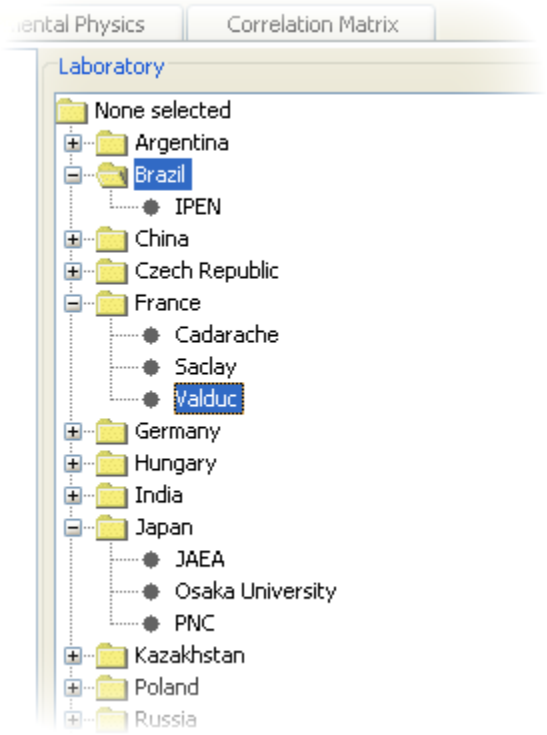


Figure 12. Hierarchical criterion.

You can select one or more items from the selection lists within a tree.

Selecting a parent node of a tree is equivalent to selecting all of its children nodes within a tree (e.g. by selecting “France” in the Laboratory tree, the database searches for all experiments performed in “Cadarache”, “Saclay” or “Valduc”).

4.2. Query Panel

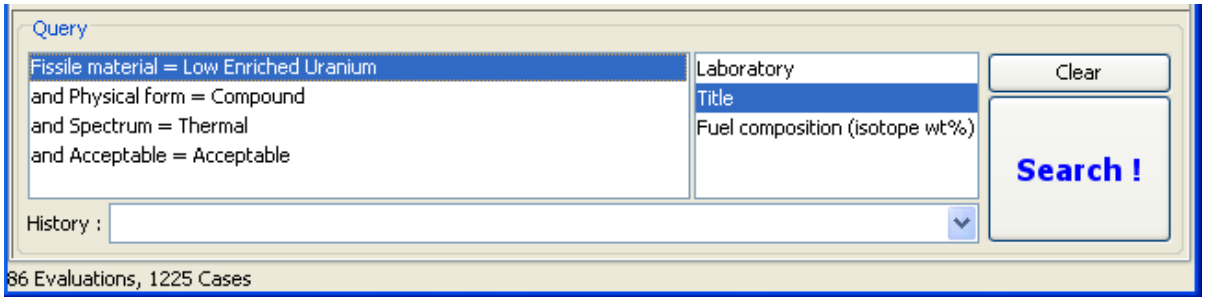


Figure 13. Query Panel.

The query pane located at the bottom of the screen displays the criteria currently set and the columns selected in the results window.

You can remove a criterion by selecting it and pressing the DEL key. The “Clear” button removes all selected criteria.

You can remove a checked results columns directly from this window by selecting it and pressing the DEL key.

Each time you add, change, or remove a criterion, the status bar is updated to display the number of evaluations and cases found in the database matching the current selected criteria.

Once the search criteria have been selected, run the query by clicking the “Search !” button. This will display the “Results” view.

Note: The “History” drop down list displays the 10 most recent executed DICE queries. To recall a previous query, select it from the list and all search criteria will be automatically set to match the previous search.

5. DISPLAYING RESULTS

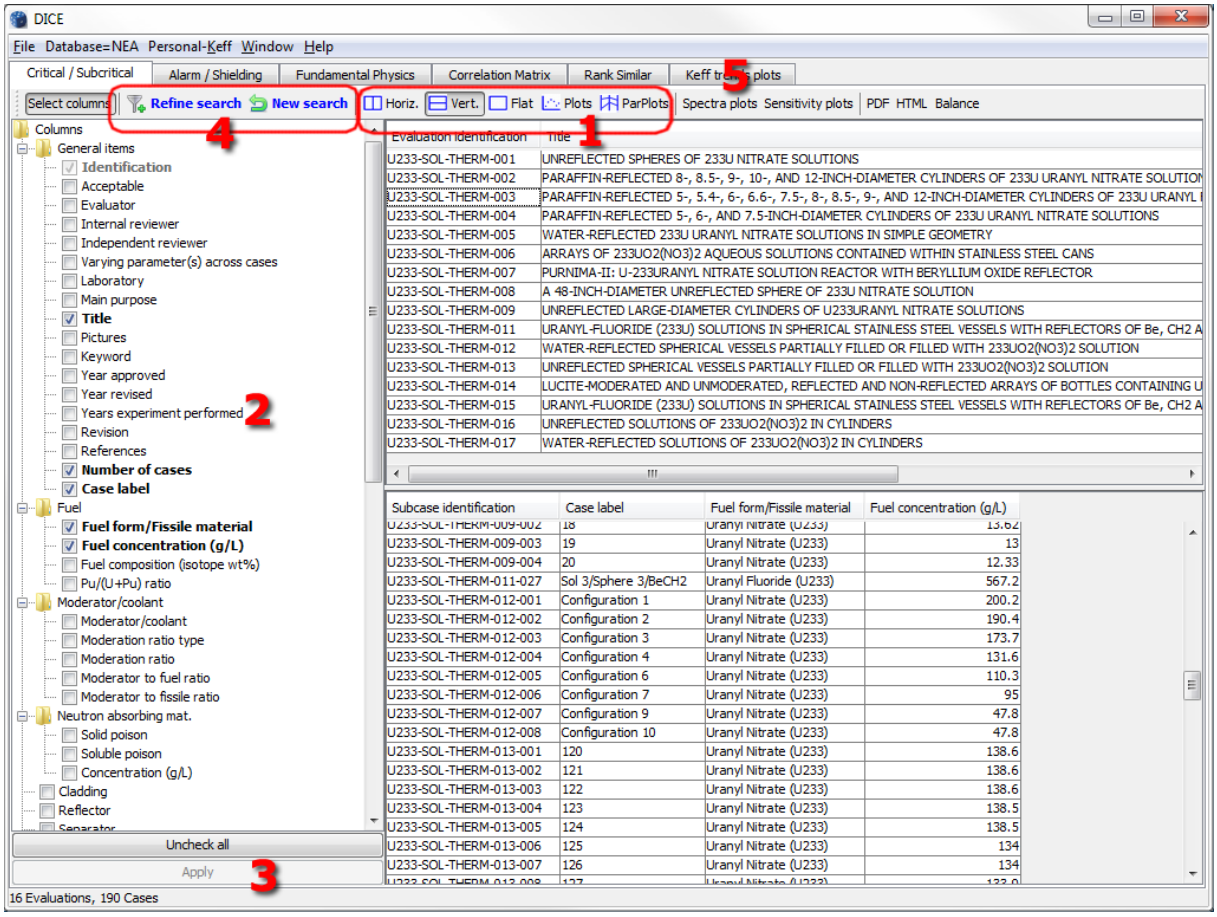


Figure 14. Results Window.

Several views are available for displaying search results, you can switch between them by using the toolbar buttons (1 in Figure 14):

- Flat table;
- Hierarchical tables (horizontal or vertical split);
- Scatter plot;
- Parallel axis plot.

Use the left tree to select the result tables/plots columns (2 in Figure 14). After making changes, press the "Apply" button (3 in Figure 14) to refresh the result views. The "Apply" button is enabled whenever a new result column is added/removed. Selected result columns are displayed in **bold**.

To return the initial search pane, you can press either the 'Refine search' button, which retains the selected columns and search criteria, or the 'New search' button which will start a blank new search (that is, with no search criteria and with only the Title, Number of cases and Case label columns selected for results display). (4 in Figure 14).

In order to enlarge the space available for the result views you can hide this tree by clicking on the "Select columns" button.

Note: You cannot uncheck the Identification column. A computed column (# cases) that displays the number of cases matching the query is automatically added.

5.1. Results Tables

To sort data, click on the desired column's header. To reverse the sort order, press the SHIFT key while clicking on the desired column header.

You can remove row(s) from the tables by selecting them and pressing the DEL key or by right-clicking the mouse to display the contextual menu and then selecting "Remove selected row(s)". To restore the initial search results, press the "Apply" button.

You can copy selected row(s) from the results tables and paste them into your text editor or Microsoft Excel.

You can reorder the results tables' columns. To do so, click on a column header and drag the mouse to the desired location.

5.1.1. Hierarchical Results Tables, Horizontal Split

This view is made of two tables separated by a vertical bar. In the left pane, the evaluation level columns are shown. In the right pane, the case level columns are shown.

The right table (case level) displays the cases for the selected evaluations in the left table or all of the cases if none are selected.

5.1.2. Hierarchical Results Tables, Vertical Split

This view is the same as hierarchical results tables, horizontal split, except the tables are split by a horizontal bar.

5.1.3. Single Result Table, Flat View

In this mode, all columns are displayed in a single table.

5.2. Results Plot View

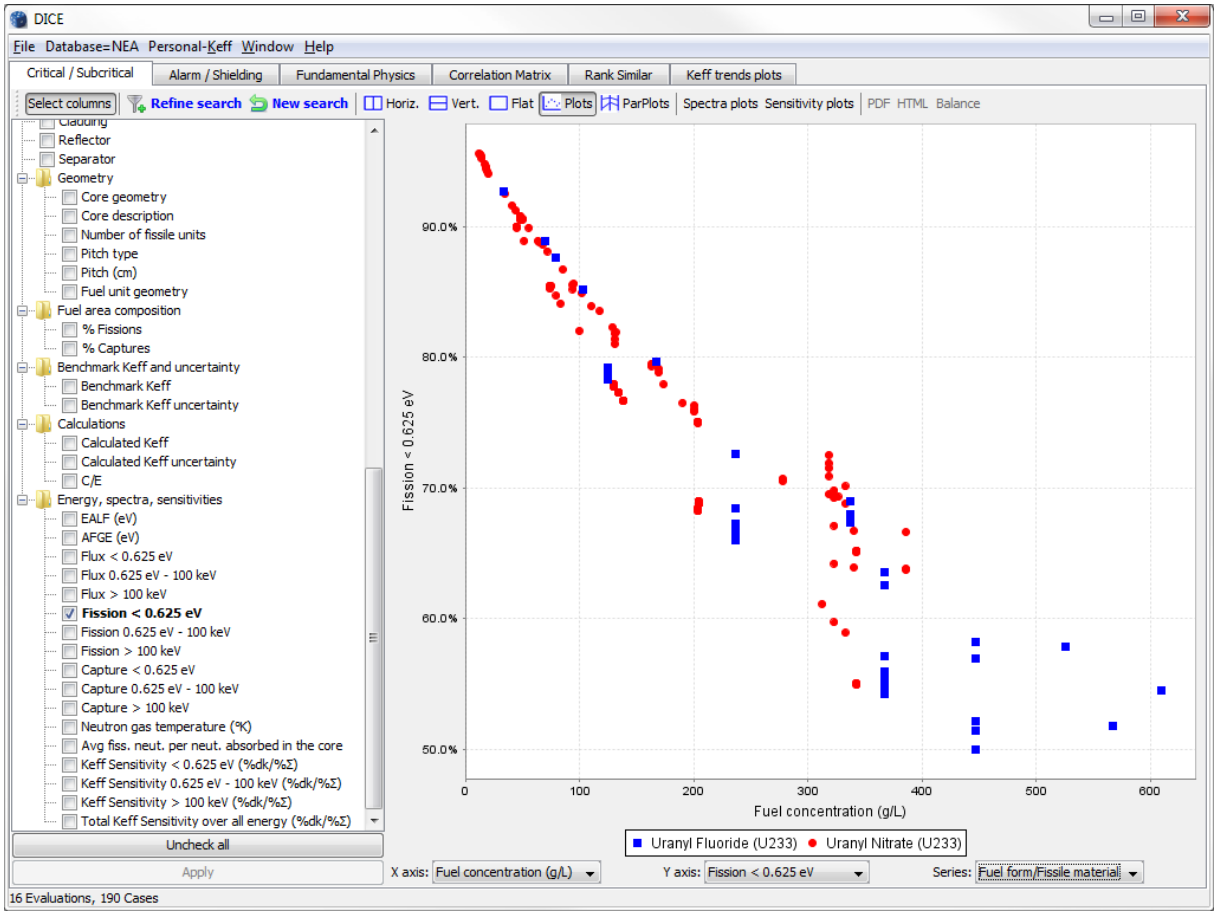


Figure 15. Results Plot View.

In order to plot certain data, you can select “X axis”, “Y axis” and “Series” among the selected results columns (see Section 5.1). At least one numerical column needs to be available in order to obtain plots. The text columns (e.g. “References”) cannot be used in plots but all others can, except for the “Y axis”, which requires a numerical column (e.g. “Number of cases”). For example, you can plot “Calculated Keff” (Y axis) against “Fuel concentration” (a numerical column) but also against “Library” or “Codename” (short text columns).

By right-clicking on the plot, a contextual menu allows you to:

- Set some plot properties (title, legend, ticks);
- Save the plot in a file;
- Print the plot;
- Zoom in or out.

You can also use the mouse to zoom in by pressing the left button and then dragging the mouse from the top-left to the bottom-right corner. To reset the zoom level, drag the mouse from the bottom-right to the top-left.

To display the data values corresponding to each point, hover the cursor over it to display a tooltip showing its coordinates.

Note: The legend is not displayed when there are more than 20 items to show. Press the "Select columns" button to enlarge the plot window.

5.3. Parallel Axis Plot View

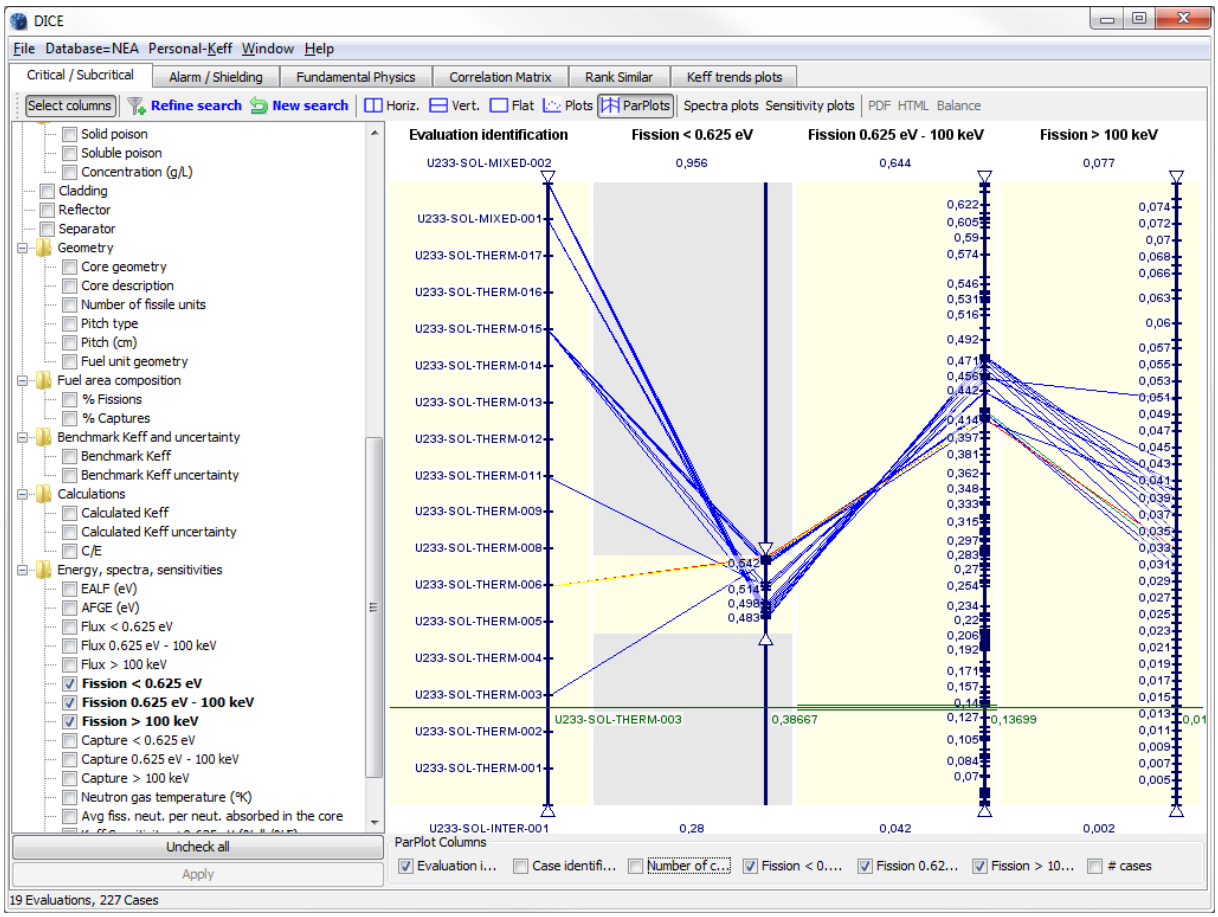


Figure 16. Parallel Axis Plot View

Parallel Axis Plots allows visualizing the relationship between DICE database values.

Search results table columns are represented as vertical axes. For each results table row a polyline links its values on each axes. See http://en.wikipedia.org/wiki/Parallel_coordinates for a longer description.

The checkboxes at the bottom allow selecting the search results columns which should be displayed as vertical axes.

Numerical fields and classification fields (e.g. Fuel form, Moderator...) can be displayed by this visualization, text ones (e.g. Title) cannot be selected, by default only the first result table columns are initially selected.

You can drill down in the values in two different ways:

- By zooming a given vertical axis : click and drag in the yellow background area or a vertical axis;
- By limiting the range of values displayed for a given axis: click on the upper/lower axes triangle and drag them to define a range, the polylines of the search results with value in this range only will be displayed.

Note:

- Axes can be reordered by clicking and dragging their titles, this is the most efficient way for revealing trends;
- Axes can be moved left and right in their vertical band : click on axis and drag it;
- The polyline segments colors express their weight, that is the number of cases that a given segment represent, the color scale used is the light spectrum from blue (low weight) to red (high weight), in current implementation the segments are not drawn in increasing weight order, so small weight ones may obscure the greatest ones;
- Double clicking on polylines will switch into a mode where all will be drawn in black and the one near the location you double-clicked will be highlighted in red;
- A contextual menu is available with a right click on the plot:
    - 'Intensity mode' controls the polylines coloring scheme;
    - 'Make uniform'/'Make all uniform'/'Reset positions' controls the distribution of numerical values along axes : according to their magnitude (the default) or evenly spaced ('uniform');
    - 'Selection dialog' bring a dialog which allow highlighting some of the results (by selecting row(s) in the table popup);
    - 'Column role', 'Column axis dimension', 'Clear all column axes' options have no effect in DICE.
- Saving with menu “File > Save” is not yet implemented, take a screenshot instead.

5.4. Evaluation PDF from the *Handbook*

After having selected a single evaluation level row, press the “PDF” button in any results table view to open the PDF file containing the evaluation from the *Handbook* (5 in Figure 14).

When an evaluation is part of a cross-references group, the user has the possibility to directly open the main evaluation PDF file.

Note: If the selected evaluation does not open, DICE was probably not able to find your default PDF reader, and you need to specify its location in the Settings dialog (see Section 3.7).

5.5. Evaluation/Case Summary in HTML

After having selected a single evaluation or a single case in any of the results tables, press the "HTML" button (5 in Figure 14) to open an HTML file displaying a summary of either the selected evaluation or the selected case.

Note: If a browser does not open, DICE was probably not able to find your default browser, and you need to specify its location in the Settings dialog (see Section 3.7).

5.6. Neutron Balance File

After having selected a single case in any of the results tables, press the "Balance" button (5 in Figure 14) to open the corresponding neutron balance file.

Note: If the balance file cannot be found, check the location of the "Balance folder" specified in the Settings dialog (see Section 3.7).

Note: Neutron balance data are currently available for about 93% of the available configurations in the *ICSBEP Handbook*.

5.7. Spectra and Sensitivity Plots

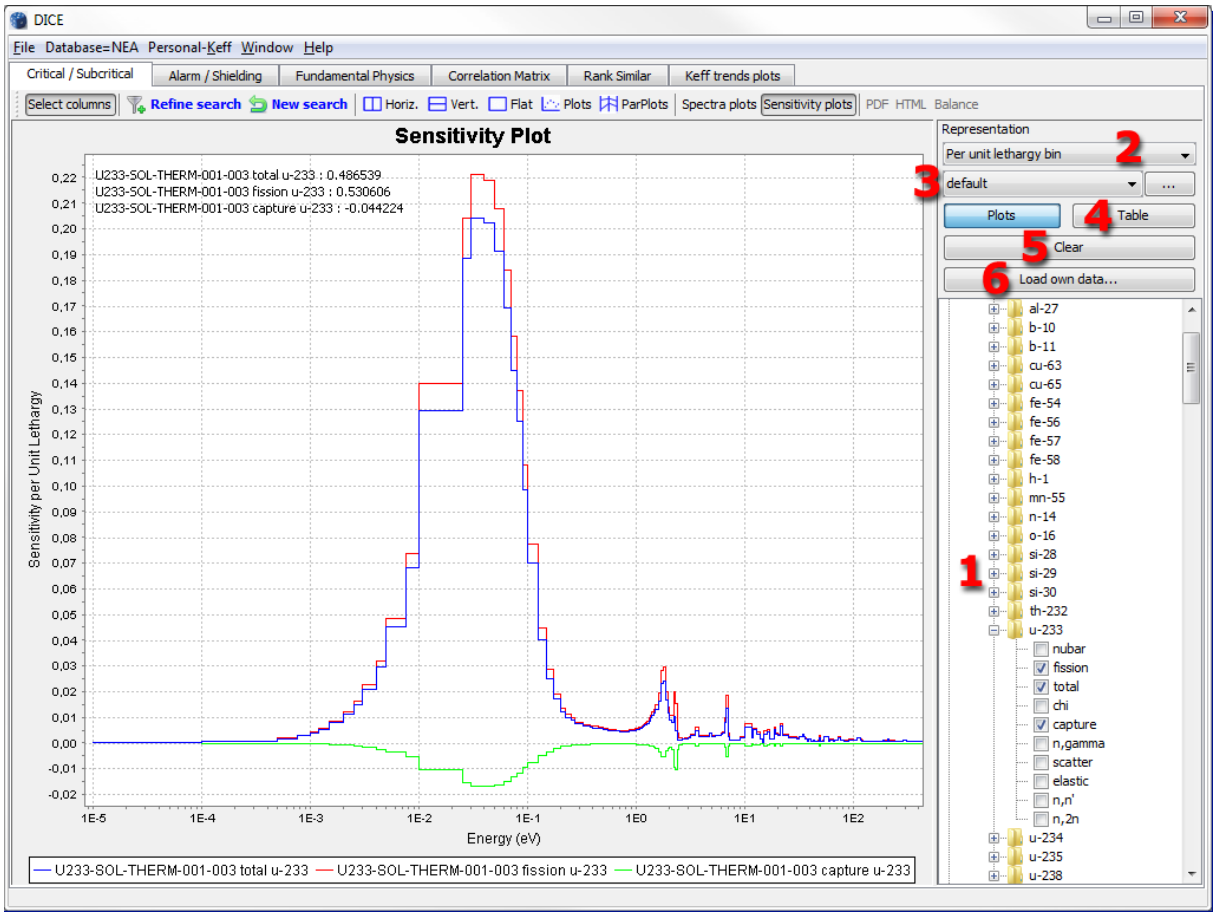


Figure 17. Sensitivity Plot.

DICE can plot spectra and sensitivity data for criticality cases. Click on the "Spectra plots" or "Sensitivity plots" buttons.

Select the dataset(s) in the tree on the lower right pane (1 in Figure 17).

Then, select the representation (2 in Figure 17):

- Y axis log (for Spectra only);
- Per unit lethargy bin/Total within bin;
- Normalization: to one or the entire reaction rate (for Spectra only);
- Energy Group structure: select one structure from the drop-down list, press the "…" button to add an energy file to this list (3 in Figure 17).

All data share the same representation. When you change the energy group structure, all plots and the table are automatically updated.

To zoom in, drag the mouse from the top-left corner to the bottom-right corner. To reset the plot to its initial zoom level, drag the mouse from the bottom-right corner to the top-left corner.

You can switch between the plots and a tabular display by using the buttons "Plots" and "Table" (4 in Figure 17).

Click on the "Clear" button to remove all plots and empty the table (5 in Figure 17).

Click on the "Load own data…" button to add a curve from a file (6 in Figure 17).

A sensitivity file must be in any of the following formats in order to plot:

- ABBN sensitivity format;
- TSUNAMI1D;
- TSUNAMI3D.

Check the corresponding button in the Open file dialog before pressing the OK button.

Note: Spectra data are currently available for only about 90% of the available configurations in the *ICSBEP Handbook*.

Note: IPPE sensitivity data are currently available for only 7% of the available configurations in the *ICSBEP Handbook* (in Volumes I and II).

Note: ORNL sensitivity data are currently available for only 8% of the available configurations in the *ICSBEP Handbook* (mainly in Volumes V and VI).

Note: NEA sensitivity data are currently available for only 70% of the available configurations in the *ICSBEP Handbook*).

5.8. Exporting Results

5.8.1. Clipboard

The DICE results tables can be copied to the clipboard by using the CTRL-C or CTRL-INS keys. Results can be pasted into Microsoft Word (as a formatted table) or Excel (as table cells) or any other text editor or spreadsheet program.

5.8.2. Files

The menu "File > Save As…" can be used to save tables or plots.

Plots can be exported as Portable Network Graphics (PNG) files.

Tables can be saved as "tab delimited" (convenient for Microsoft Excel or any other spreadsheet program) or "Comma Separated Values" (CSV) files.

Use the export dialog to set the delimiter:

- Tab;
- Semicolon;
- Comma;
- Other (type a delimiter in the box below).

Then set the encoding:

- ASCII (non-ASCII characters will be converted, e.g. 'δ' will be converted into 'delta');
- Unicode (no conversion of characters).

6. CORRELATION MATRIX PANE

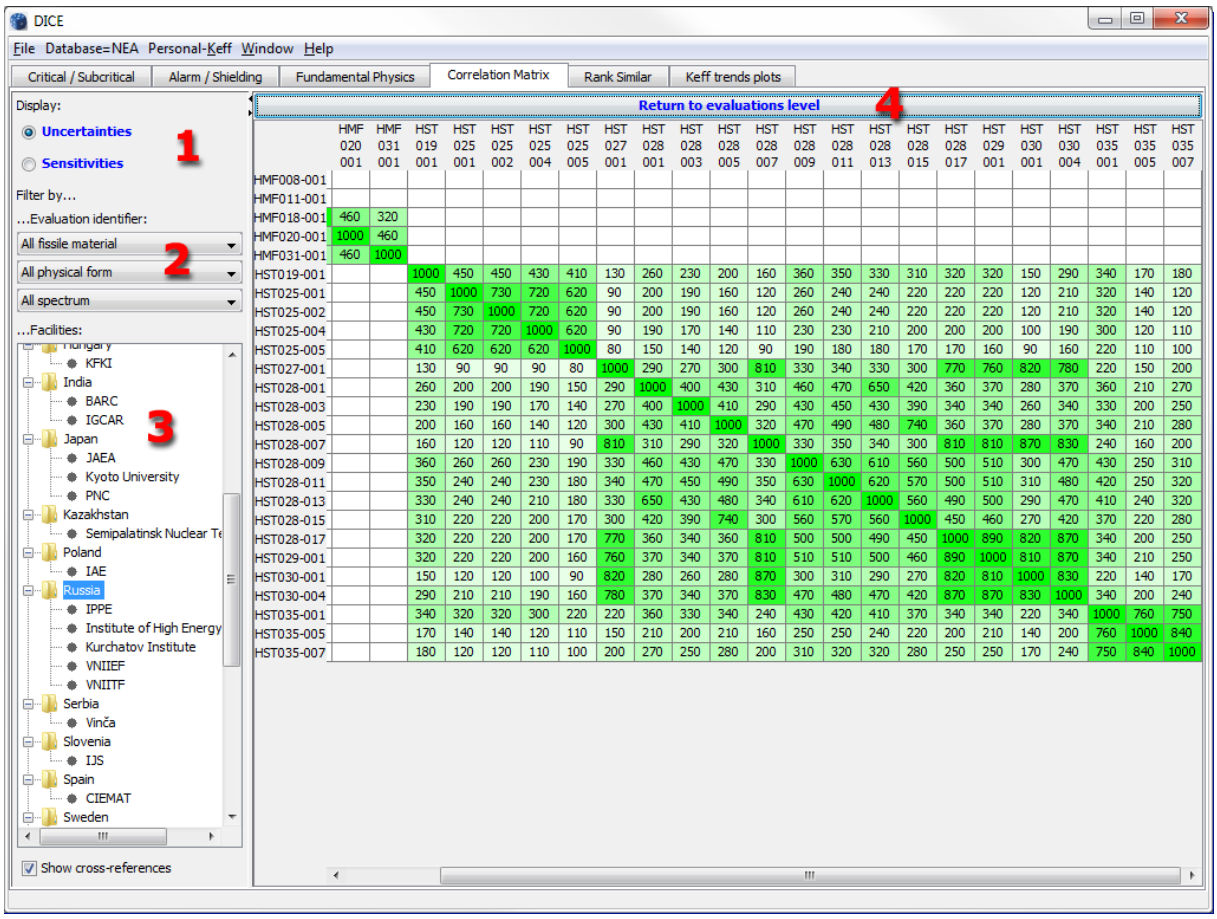


Figure 18. Correlation Matrix Window.

The correlation matrix window is split into two panes. The left pane allows you to select the correlation matrix to display (1 in Figure 18) and narrow the display by evaluation IDs or by nuclear facilities. The right pane displays the correlation matrix.

You can display certain parts of the correlation matrix by filtering on the following criteria:

- Evaluation identification: the three drop-down menus on the upper left (2 in Figure 18);
- Country/facility by using the tree (3 in Figure 18);
- Cross-references: check or uncheck the “Show cross-references” check box.

At the evaluation level when correlations of uncertainties is selected, the matrix cells will have the following attributes:

- Empty when there is no correlation;
- A “+” sign to indicate correlation;

- A "(+)" symbol to indicate a 100% correlation;

- Teal when there are case level data available, or bright blue otherwise.

Note: The "(+)" symbol appears outside the diagonal when an evaluation has many identifiers in the *ICSBEP Handbook* (i.e. is a cross-reference).

At the evaluation level when correlations of sensitivities is selected, the matrix cells will have the following attributes:

- Empty when there is no correlation;

- A numeric values between -1000 and 1000 displaying the evaluation level correlation which is just the average of the case level correlations between the evaluations.

Note: Due to the definition above, evaluations often do not have a correlation value of 1000 with themselves. This is because all correlations analysis should be done at the cases level, and the evaluation level provides an overview of case level data.

At the case level, the matrix cells may be:

- Empty when there is no correlation or the correlation coefficient is not known;

- Colored with shades of green, brighter green being closer to 1000.

To switch between evaluation and case levels click the "Show cases level details" at the top of the matrix window and "Return to evaluations level" buttons (4 in Figure 18).

When no correlation coefficients (cases level) are available in the database, the message "Sorry, no case/case correlation coefficients available..." is displayed.

Note: You can select multiple cells by holding the CTRL key while selecting cells or dragging the mouse to select a sub block from the matrix.

7. RANK SIMILAR PANE

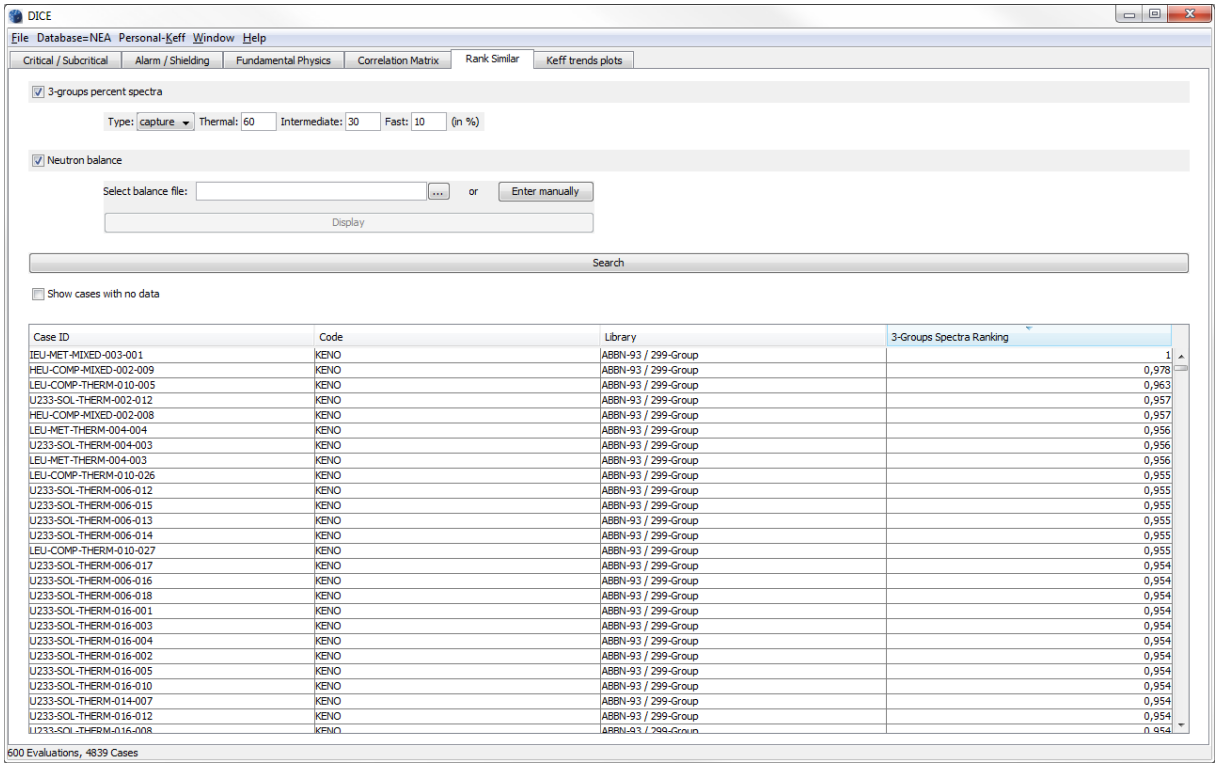


Figure 19. Rank Similar Pane

The Rank Similar pane allows users to rank benchmarks based on 3 group fluxes and neutron balance data.

The pane applies a Euclidean distance metric to the 3 group flux, capture, fission or neutron balance, and returns a sortable list with the case identifier, code, library and ranking. The rankings are normalised on a scale where the most similar system is given a numerical value of 1, and the least similar is assigned a value of 0. An example of a search where the user inputs the percentage of fissions in 3 groups is shown in Figure 19.

Cases that do not have calculated spectra data (approximately 10% of cases) can be returned in the list using the check box, 'Show cases with no data'. The similarity is left blank for these cases.

For 3- group percent fission the metric and neutron balance information the similarity metric used is:

$$1 - \frac{\sqrt{(p_1 - q_1)^2 + (p_2 - q_2)^2 + \ldots + (p_N - q_N)^2}}{\sqrt{2|p||q|}}$$

Where p is system one, q is system two. For multi-group fission, N is the percentage of fission in each group, while for neutron balance, N is the capture, and fission for each **element, except that for fissile elements the distance is by isotope**.

8. K_{EFF} TREND PLOTS PANE

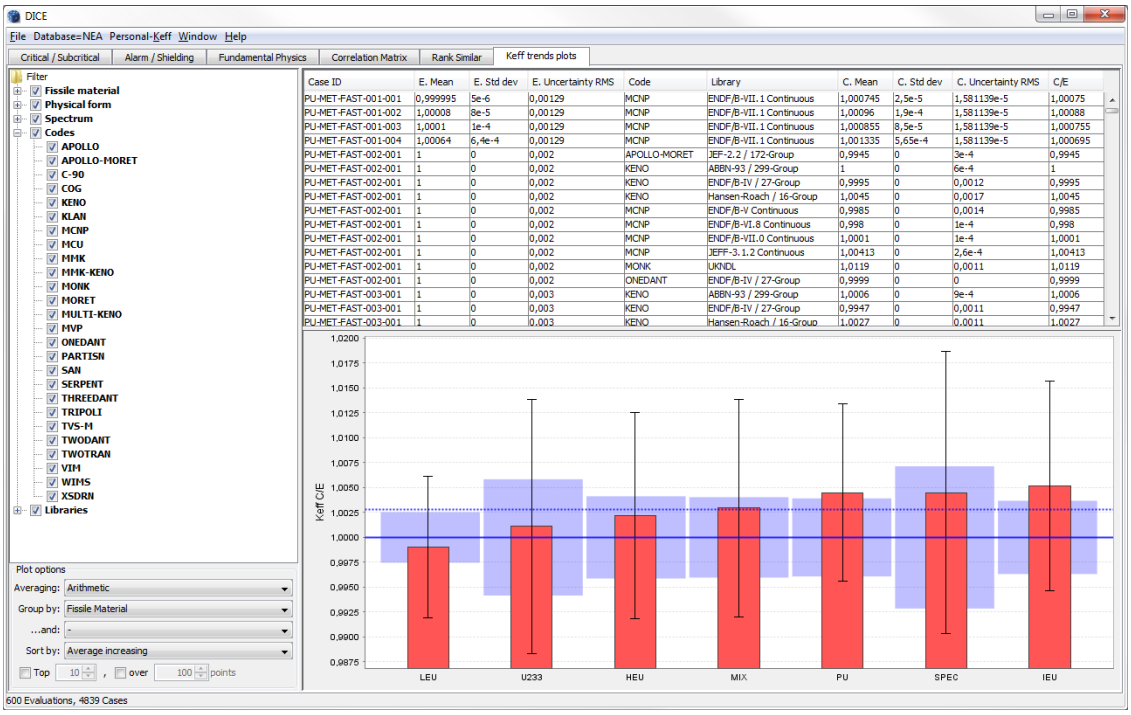


Figure 20. k_{eff} trend plots example

Bars Correspond to Average Values:

Each red bar represents an average value. To display additional information about the number of points used in the average or the value and standard deviation, hover the cursor over the bar. The averaging for each bar can be performed via four methods using "Averaging" drop down box. Each option is briefly explained below.

In all formula, N is the points at which both a C and an E value exist.

ARITHMETIC

$$\frac{\sum_N C_N/E_N}{N}$$

GEOMETRIC [4]

$$\left(\prod_N \frac{C_N}{E_N}\right)^{\frac{1}{N}}$$

In the case of a negative C/E, the geometric mean is calculated by separating the positive and negative components, computing the geometric mean of each, and then computing a weighted average of the two geometric means, where the average is weighted by the number of data points [5].

WEIGHTED BY VALUE

$$\frac{\sum_N W_N C_N / E_N}{\sum_N W_N}$$

With W

$$W = 0.5 \times (C_N + E_N)$$

WEIGHTED BY UNCERTAINTY

$$\frac{\sum_N W_N C_N / E_N}{\sum_N W_N}$$

With W

$$W = \frac{1}{\sigma^2}$$

where

$$\sigma^2 = \frac{{\sigma_E}^2 + {\sigma_C}^2}{2}$$

Uncertainty associated with each bar from averaging of multiple data points: Standard deviation bars

The standard deviation uncertainty line corresponds to the standard deviation of all C/E values within a data set. In Figure 20 for example, in the HEU column the standard deviation marker is the standard deviation of all C/E's for HEU cases.

Correlations should be taken into account; however there is not sufficient information within the database to include correlations at this point.

Note: The user will encounter **E.Std dev** and **E. Uncertainty RMS.** The first occurs when multiple models have been collapsed, and the value represents the standard deviation of the benchmark **experimental** model k_{eff}. The second is not an RMS in DICE, it is simply the benchmark model uncertainty, while C.Uncertainty RMS is simply the uncertainty in the calculated k_{eff}.

Plots with Multiple Levels

In the plot options two levels of detail can be selected. The first controls the values that will be plotted on the x-axis; the second level controls the number of bars in the first level, each with a distinct colour.

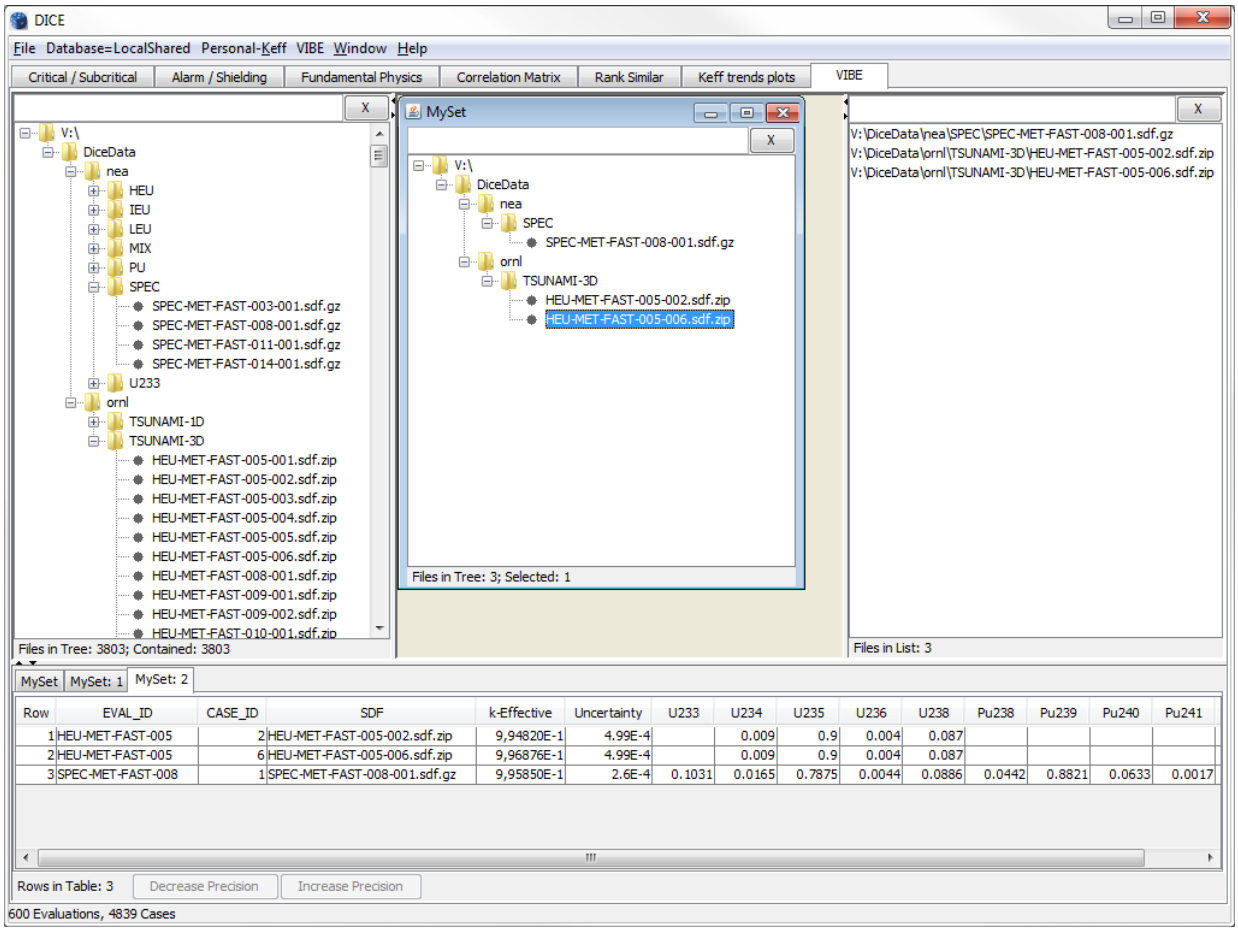
The blue band uncertainty is the combination of the E. Uncertainty RMS (benchmark uncertainty) and C.Uncertainty RMS (calculated uncertainty). When collapsed over multiple evaluations or cases, the RMS of all the collapsed cases is calculated. This blue bar is present only when the user selects "None" for the second level of plotting.

Filters

Specific data can be selected by applying combinations of the filters present on the left.

Note: If the user unchecks all boxes no filter is applied, since otherwise the results would be empty.

9. PLUGINS



Row	EVAL_ID	CASE_ID	SDF	k-Effective	Uncertainty	U233	U234	U235	U236	U238	Pu238	Pu239	Pu240	Pu241
1	HEU-MET-FAST-005	2	HEU-MET-FAST-005-002.sdf.zip	9,94820E-1	4.99E-4		0.009	0.9	0.004	0.087				
2	HEU-MET-FAST-005	6	HEU-MET-FAST-005-006.sdf.zip	9,96876E-1	4.99E-4		0.009	0.9	0.004	0.087				
3	SPEC-MET-FAST-008	1	SPEC-MET-FAST-008-001.sdf.gz	9,95850E-1	2.6E-4	0.1031	0.0165	0.7875	0.0044	0.0886	0.0442	0.8821	0.0633	0.0017

Figure 21: VIBE Pane

9.1. Introduction

DICE enables the integration of third party tools (plugins). Each plugin is displayed in its own tab allowing users access to the plugin functionality without exiting DICE or launching both tools.

A Java API is also available for developers wanting to programmatically retrieve data from DICE database from their tools. Contact NEA for more details: dice@oecd-nea.fr.

9.2. VIBE

VIBE is a new graphical user interface created to identify and interpret sensitivity data from SCALE/TSUNAMI that is distributed with SCALE 6.0. It enables users to:

- Group collapse sensitivity data;
- sort and filter the collapsed data so as to identify important processes in applications or experiments;

- Provide an improved means of preselecting experiments for use in criticality code validation.

VIBE also enables users to query the DICE database to gain more information about experiments present in the database. VIBE also supports other sensitivity data distributed with the 2014 release of the ICSBEP Handbook.

To use VIBE as a DICE plugin, please use the `vibe-dice.bat` batch file on Windows or the `vibe-dice.sh` script file on UNIX/Linux.

To access VIBE, select the VIBE tab. When the VIBE tab is selected, the "VIBE" menu located in the top menu bar is enabled. From then on, you can use VIBE in DICE.

Note: To start without the plugin, use the `dice.bat/dice.sh` batch files to launch DICE.

For the time being, the VIBE plugin can only access the "LocalShared" database when copied on a local hard drive, or the "Local" database when DICE runs directly on the DVD.

Note: Plugin instructions are not provided in this manual, see http://scale.ornl.gov/vibe/.

10. TROUBLESHOOTING

10.1. Known Problem(s)

This table lists all known problems and their solutions:

Problem description	**Solution**
Figures are displayed with a comma instead of a dot as the decimal separator or vice versa	You can override your language settings to American-English by adding the following command line options to the `dice.bat` or `dice.sh` file: `-Duser.language=en -Duser.country=us` Refer to http://www.oracle.com/technetwork/java/javase/javase7locales-334809.html for technical details.
DICE results tables contains strange characters (e.g. square boxes or question marks)	This problem can stem from missing fonts. Try the following: On Microsoft Windows, select Add/Remove programs in the Control Panel. Be sure that the optional feature "Additional Fonts and Media Support" is installed on the local hard drive. To check that all fonts are installed, browse your Java home directory and the lib\fonts subdirectory.
VIBE tab does not appear although I have VIBE correctly installed on my system	Make sure you have used the `dice_vibe.bat` file to launch DICE (See Section 9).

10.2. Startup Problem(s)

DICE cannot start if it cannot connect to any database. If this occurs, you will obtain the following dialog:

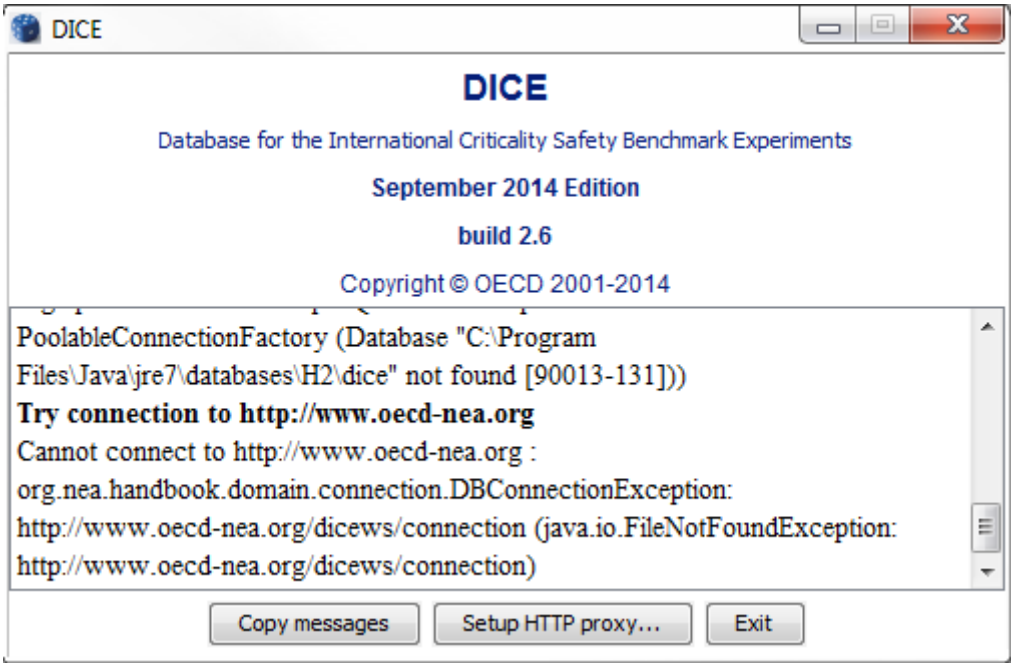


Figure 22. No Connection Dialog.

If you are trying to connect to the NEA master database (see Section 3.0), first check if the NEA website is currently accessible (www.oecd-nea.org). If you need to connect through an HTTP proxy, click on the "Setup HTTP proxy…" button to open the Settings dialog. Restart DICE for the settings to take effect.

If you are trying to connect to a local database (see Section 3.0), check that the data files exist on the media (DVD or computer) and that you have read access.

If you still cannot connect to either master database, please send an email message containing the error messages to dice@oecd-nea.org. You can copy these messages to the clipboard by using the "Copy messages" button.

10.2.1. Windows

To track down start up problems on Windows, follow these instructions:

1. Determine if you have a suitable Java environment.

2. Open a command window (Start menu > Run…) then type cmd.

3. In the Command Prompt window, issue the `java -version` command.

4. If you see the following message, your computer does not have Java properly installed:

```
C:\>java -version
'java' is not recognized as an internal or external command,
operable program or batch file.
```

If this is the case, check that the PATH environment variable is correctly set. Alternatively, Sun Microsystems offers a web page to verify your Java installation at www.java.com/en/download/installed.jsp.

You can download Java from www.java.com or alternatively install it from the DVD in the Dice\java folder. (You should use a JRE 1.6 version at a minimum). Once this is done, go to the DICE\software folder and type the following command:

```
java –jar Dice.jar
```

DICE should now open. If not, to request further help, if there are error messages in the console, right-click in the title bar, choose menu "Select all", then "Copy", and send the text in the clipboard to the DICE developers (dice@oecd-nea.org) for assistance.

10.2.2. Linux/UNIX

To troubleshoot problems on Linux, follow the below instructions:

First, make sure your Java installation is correct with the following command:

```
java –version
```

You may need to put the full path to your Java executable in the `dice.sh` script and make sure that it has execution rights.

10.3. Speed Problem(s)

The following tips will improve execution speed:

- Copy the DVD onto your hard drive instead of running from the DVD drive
- Connect to the NEA remote database
- Narrow the search to a few evaluations before pressing the "Search !" button
- Display only relevant columns in result views.

10.4. Memory Problem(s)

Java programs need to specify the maximum memory they can use. With a Sun Microsystems Java Machine this setting must be set by command line (or in the BAT or SH file). The memory limit used by DICE is set in the `dice.bat` file (or `dice.sh` for Linux):

```
-Xmx512M
```

The above option -Xmx512M specifies that DICE will take at most 512Mbytes of memory. If you have more physical memory (e.g. 1GB, or more), you can edit this command line and replace the option -Xmx512M with -Xmx1024M. For example to allow DICE to use at most 1GB of memory, the `dice.bat` file should be:

```
-javaw -Xmx1024M -jar Dice.jar
```

10.5. Bug Report Dialog

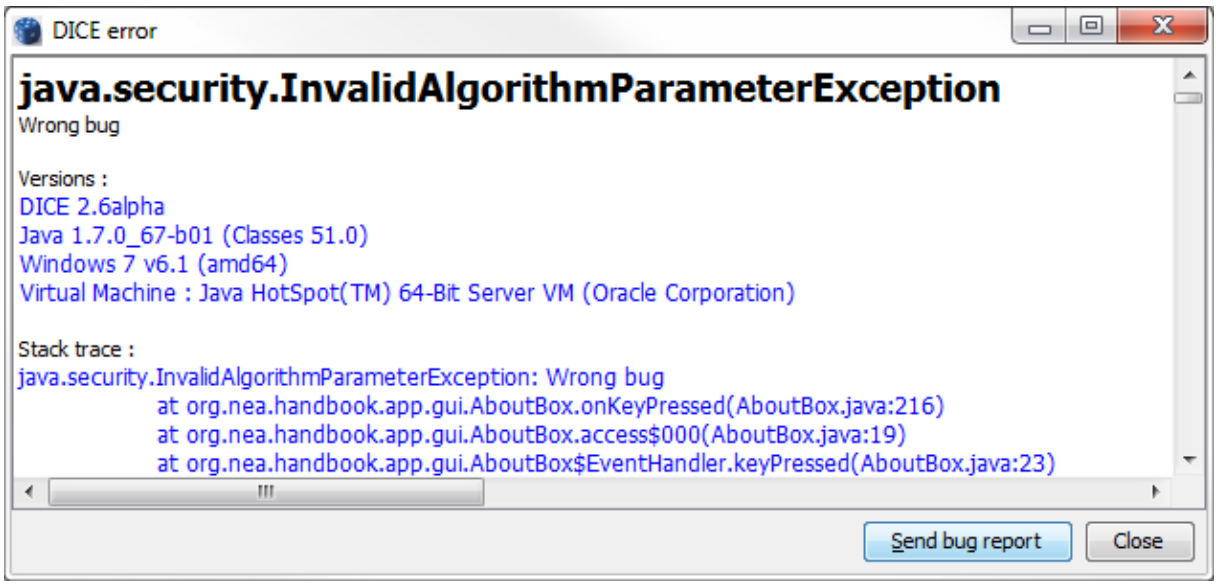


Figure 23. Bug Report Dialog.

The "Bug report" dialog is shown when a problem occurs in the DICE software. This dialog contains useful information for developers and allows you to send an automatic report to them.

Clicking the button "Send bug report" will bring up a dialog allowing you to enter your name, email address, and explanatory text.

Filling in these fields are optional but consider inputting your email address so that you can receive an answer.

Note: Your email address will not be used for any other purpose.

The Bug report functionality can only detect a programming bug (i.e. misuse of software API).

To submit a manual bug report or a software enhancement request, please send an e-mail to dice@oecd-nea.fr. Please include the following information:

- Screen captures;
- Your environment (Operating System and Java version);
- DICE version.

This information can be found in the "About" dialog (see Section 3.8).

11. A GLOSSARY OF DICE TERMS FOR CRITICAL AND SUBCRITICAL MEASUREMENTS

The user selects from a set of search criteria given in the search window to query the DICE database. As shown in Figure 1, the search parameters are grouped into 10 themes:

- General items
- Fuel
- Moderator / coolant material
- Cladding material
- Reflector material
- Neutron absorbing material
- Separation material
- Geometry
- Benchmark k_{eff} and calculations
- Energy, spectra, sensitivities

The outcome or result of submitting a query is displayed in the "Result" window. It may be noted that this window now includes an additional theme: Fuel area composition, which has been inserted after the "Geometry" and before the "Energy and spectra" themes.

Generally, items selected in the Search window, i.e., the search parameters, are then displayed in the Result window. That is, in general the terms or parameters presented in the Search window can (and will) be displayed in both the Search and the Result windows. However, there are some terms or parameters which, though not part of the search parameters, can be requested (displayed) in the result window and therefore appear only in the result window. Good examples of this type of parameter include the items in the "Fuel area composition" theme, which are displayed only on the Result window. Additionally there exist only a very few unique cases where parameters specified in the Search window are not displayed in the Result window. Therefore, it can be assumed by the reader that all of the following terms in the glossary appear in both the Search and the Result windows, except where explicitly noted to appear in only the Search window or only the Result window.

The glossary items are now discussed below in the same order as the 12 themes shown in the Result window (Figure 24).

Unless otherwise specified, for recent evaluations (written after 2008) the data were entered into DICE by copying information from an Excel spreadsheet provided by the evaluator(s). For earlier evaluations, all the data were extracted from the Handbook and entered manually. The data correspond to the benchmark models of experimental configurations described in Section 3, which can be different from the description of experimental configurations presented in Section 1.

Parameters followed by an asterisk are displayed only in the Result window.

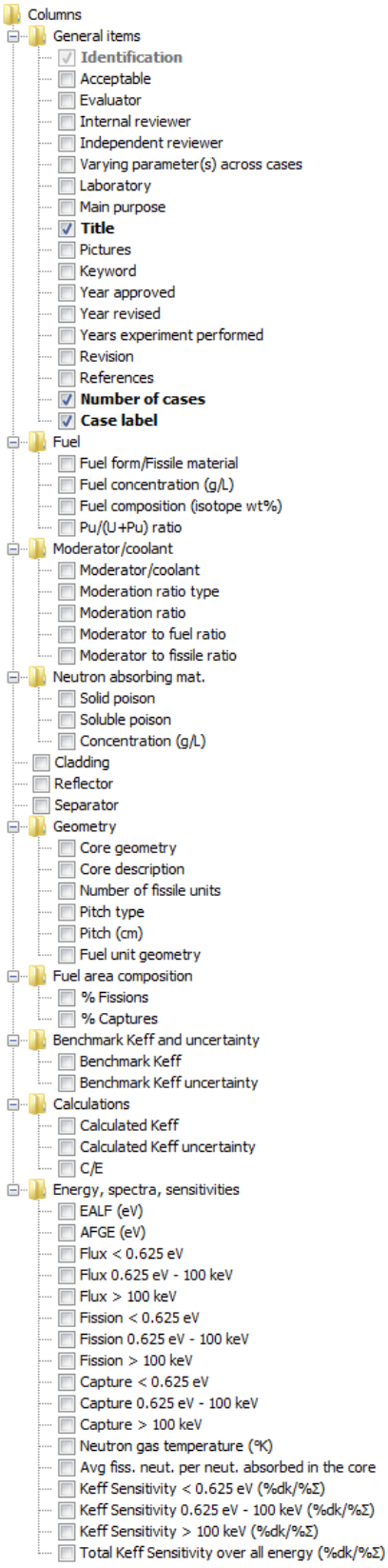


Figure 24. Partial View of the Result Window

11.1. General Items

The data or parameters in this theme or group are provided for all evaluations.

Identification

A unique identifier for each benchmark evaluation that takes the form:

Fissile Material – Physical Form – Spectrum – Three-Digit Numerical Identifier

such as PU-MET-FAST-003 for fast, plutonium system in which the fissile material is in the form of a metal. In the case of subcritical experiments, the above identifier string is preceded by 'SUB-', such as SUB-PU-MET-FAST-001 for subcritical measurements of metal plutonium systems with fast spectrum. This identifier is documented at the top of each page of the evaluation. On the Search page this parameter may be set to "Critical," "Subcritical," or "Critical and Subcritical."

The subdivision into fast, intermediate, thermal, and mixed spectra systems depends upon the neutron energy range where the majority of the fissions occur. In the Handbook, fast, intermediate, and thermal systems are defined as systems in which more than 50% of the fissions occur at energies > 100 keV, 0.625 eV - 100 keV, and < 0.625eV, respectively. Systems for which more than 50% of the fissions do not occur in any one of these three energy ranges are classified as "mixed" spectra systems. Cross references are included in the ICSBEP Handbook and in DICE for experimental series containing data that may be categorized by more than one energy range. For example, series MIX-MISC-FAST-001 is comprised of 11 experiments of which only three configurations (Cases 9, 10, and 11) are appropriately categorized as MIX-MISC-FAST systems. The other configurations are categorized differently and presented in DICE under the identifiers shown in Table 1.

Table 1. Example of cross reference identifiers for configurations published in the Handbook under identifier MIX-MISC-FAST-001.

Case #	Identifier in DICE
1, 2, 3	IEU-MET-FAST-017-001, -002, -003
4, 5, 6	IEU-COMP-INTER-002-004, -005, -006
7, 8	MIX-MET-FAST-015-007, -008
9, 10, 11	MIX-MISC-FAST-001-009, -010, -011

Acceptable/Not Acceptable

Parameter indicating whether the evaluation of an experiment was determined by the *ICSBEP* to be acceptable (or not) for use as a critical or subcritical benchmark experiment. That judgment is documented in Sections 1.1 and 2 of an evaluation. Additionally, the total number of acceptable and not acceptable cases (indicated by "Number of cases") for each evaluation is displayed (only) in the Results window. For unacceptable configurations, data are provided only in theme "General Items."

Evaluator/Internal/Independent Reviewer

Names of evaluator(s) and internal and independent reviewer(s) as documented on the Title Page of each evaluation. Additionally, the country with which they are associated is indicated for each evaluator and/or reviewer.

Varying parameter(s) across cases

Parameters of the experimental configurations that are varied for the cases within the evaluation to study the impact of the variation on criticality. These are often identified in Section 1.1 of each evaluation.

The varying parameters are: absorber material, absorber material thickness, acid molarity, array configuration, array size (number of units), assembly configuration, fuel composition, fuel concentration, geometry, interstitial material, lattice pitch, mass of individual units, moderation degree, moderation level, not applicable (single case), position of rods, reflector location, reflector material, replacement material, separating material thickness, separation material, size of units, solution height, and temperature.

Laboratory

Laboratory or organization where the experiment or series of experiments was performed (as documented in Section 1.1). In the Search window these are arranged by country, then laboratory or organization.

Main Purpose

Main purpose for performance of the experiment by the laboratory or organization. This is often discussed in Section 1.1.

The main purposes are: burnup credit, dry fuel storage, fuel fabrication, interaction, MOX applications, physics measurements, reflector test, reprocessing, solution storage, transportation and storage, waste matrix, and wet fuel storage.

Title

Title of the evaluation. The title is given on the Title Page and repeated on the first page of the evaluation.

Keywords

A list of words that describe the evaluation as provided on the first page of the evaluation (e.g., acceptable, fuel type, geometry, moderation material, reflection material, unacceptable, etc.).

Dates (evaluation and experiment)

The year(s) when the experiment or series of experiments was performed (as documented in Section 1.1) as well as the most recent year when the evaluation was revised (if it has been revised) and approved (as documented in the footer of each page). For the year(s) when the experiment or series of experiments was performed, a start date and end date are provided for each evaluation.

Revision*

The revision number of the evaluation (as documented in the footer of each page). If the current evaluation is the original, this is indicated by a revision number zero.

References

A list of formally published documents that contain relevant information about the experiment. These are provided in Section 5.

Number of cases*

Total number of evaluated configurations within a series including the configurations rejected by the *ICSBEP* (as documented in Sections 1.1 and 2).

# of cases*

Total number of acceptable configurations within a series that match the search criteria.

Label*

Identifying name/number of the experiment used in the evaluation, as indicated in the reference documents.

Case Number*

The sequential number of the configurations that are considered as acceptable benchmarks by the ICSBEP. The case numbers may appear in Sections 1 and 2, but will always be identified clearly in Sections 3 and 4 of the evaluation.

11.2. Fuel

Fuel may be characterized by Fuel form/Fissile material, Fuel region, U and Pu weight percent, and/or Pu/(U+Pu) ratio. Each is described below.

Fuel form/Fissile material

The data or parameters in this group are common to all the experiments.

The chemical form of the fuel in the evaluation (i.e., compound, metal/alloy, and/or solution). A list of fissile materials is given for each fuel form. (The list of fissile materials provides information on the fissile nuclides or isotopes and their chemical form and gives more detail than the Fissile material used in the Identification).

Fuel concentration (g/l)*

Concentration of fissile material for homogeneous-fueled solution experiments. This entry is left blank for experimental configurations other than solutions.

Fuel region

List of isotopes contained in the fuel region, irrespective of their effect on reactivity of the benchmark model. Note: this list appears only in the Search window. Isotopes selected in the fuel region can be used to filter the set of experiments obtained in the search, i.e., experiments appearing in the Result window.

Fuel composition (wt%)*

List of each isotope within the fuel and the corresponding weight percent.

U and Pu weight percent

Weight percents of the U and Pu isotopes. Note: this list appears only in the Search window. Ranges of isotopic fractions in the fuel region can be specified and used to filter the set of experiments obtained in the search, i.e., experiments appearing in the Result window.

Pu/(U+Pu) ratio

Ratio of the sum of the atom-densities of the Pu isotopes to the sum of the atom-densities of the U and Pu isotopes. This ratio is listed as "0" for cases where U is present without Pu and as "1" for cases where only Pu is present.

The data for "Fuel region," "Fuel composition," "U and Pu atom percent," and "Pu/(U+Pu) ratio" automatically generated using homogenized core atom-densities provided in balance files or fuel material atom-densities provided in Section 3.3.

11.3. Moderator/Coolant

The data or parameters in the below groups are provided for most moderated and/or cooled experiments within an evaluation and are periodically updated. These values are provided in Section 3.

Moderator/Coolant material

Moderator – a material present in the system to reduce the energy of the neutrons.

Coolant – a material in an assembly or reactor mock-up that represents/simulates a reactor coolant.

"None" indicates that neither moderator nor coolant materials are present.

The moderator/coolant materials are: alcohol, beryllium, beryllium oxide, cellulose acetate plastic, graphite, lead, lithium, Lucite/Plexiglas, mercury, oil, polyethylene, polystyrene, sodium, Teflon, uranium hydride, water (heavy water), water (light water), wax and zirconium hydride.

V_{mod}/V_{fuel} ratio*

The V_{mod}/V_{fuel} ratio is limited to heterogeneous systems with fuel rod assemblies and plate type fuel. It refers to the ratio of moderator volume to fuel volume in the equivalent fuel cell (the volume of fuel clad is not included in either fuel or moderator). If there is a hole in the fuel rod, its volume is excluded from the fuel volume.

Moderator to fuel ratio*

Moderator-to-fuel atom-density ratio refers to the ratio of moderator atom-densities to heavy metal atom-densities in the homogenized core. This information is not currently available for some moderated experiments, but is being updated as balance files are calculated.

These data are automatically generated using homogenized core atom-densities provided in balance files or atom-densities provided in Section 3.3.

Moderator to fissile ratio*

Moderator-to-fissile atom-density ratio refers to the ratio of moderator atom-density to fissile-isotopes atom-density in the homogenized core. This information is not currently available for some moderated experiments, but is being updated as balance files are calculated.

These data are automatically generated using homogenized core atom-densities provided in balance files or atom-densities provided in Section 3.3.

The data or parameters in the groups below (i.e., "Cladding material," "Reflector material," "Neutron absorbing material," "Concentration," and "Separation material") are provided for each experiment within an evaluation, as appropriate (as documented in Section 3).

11.4. Cladding Material

The specific material of the layer covering the basic fuel unit that prevents radioactive fission fragments or fuel particles from escaping the fuel. When cladding material is not present in an experimental configuration, this is indicated by "None."

The cladding materials are: aluminum, carbon steel, hastelloy, lacquer, nickel, niobium, plastic tape, polyethylene, stainless steel, Teflon, zircaloy, and zirconium-niobium alloy.

11.5. Reflector Material

The material of the region surrounding the core whose purpose is to return a portion of leaking neutrons to the core by scattering. When reflector material is not present in an experimental configuration, this is indicated by "None."

The reflector materials are:

- Aluminum materials: Aluminum, Aluminum Oxide , Duralumin (Al, Fe, Cu)
- Beryllium materials: Beryllium, Beryllium Oxide
- Borated materials: Borated Concrete, Borated Uranyl Nitrate (B, U, N, H, O), Borated Light Water, Borated Polyethylene, Boron
- Cadmium
- Carbon materials: Borated Concrete, Borated Polyethylene, Carbon Steel, Concrete, Graphite, Lucite/Plexiglas (C, H, O), Molybdenum Carbide, Oil (C, H), Paraffin (C, H), Polyethylene, Tungsten Carbide
- Cobalt
- Copper materials: Copper, Duralumin (Al, Fe, Cu), Ni-Cu-Zn Alloy

- Iron materials: Carbon Steel, Duralumin (Al, Fe, Cu), Iron, Stainless Steel (Fe, Cr, Ni)
- Lead
- Lithium Deuteride (Li, D, O)
- Magnesium
- Molybdenum materials: Molybdenum, Molybdenum Carbide
- Nickel materials: Nickel, Ni-Cu-Zn Alloy
- Poly materials: Borated Polyethylene, Polyethylene
- Silicon Dioxide
- Sodium
- Steel materials: Carbon Steel, Stainless Steel (Fe, Cr, Ni)
- Thorium
- Titanium
- Tungsten materials: Tungsten, Tungsten Carbide
- Uranium materials: Borated Uranyl Nitrate (B, U, N, H, O), Depleted Uranium, Depleted Uranium Dioxide, Uranyl Nitrate, Highly Enriched Uranium, Natural Uranium, Uranium Dioxide
- Vanadium
- Water: Borated Light Water, Heavy Water (D, O), Lithium Deuteride (Li, D, O), Water

11.6. Neutron Absorbing Material

Neutron absorbing material with a large neutron absorption cross section, also called absorber or poison, which is inserted into the experimental configuration to study its effectiveness in lowering the reactivity of fuel and/or any material that lowers to a considerable degree the reactivity of the benchmark configuration, which are selected based on the percent of captures by isotope over core given in "Spectra" Section (Table 2). Two lists of absorbing materials are provided: solid absorbers in and soluble absorbers. When neutron absorbing material is not present in an experimental configuration, this is indicated by "None."

The solid neutron absorbing materials are:

- Aluminum materials: Aluminum ; Aluminum Oxide ; Boral (B, Al, Na, Si)
- Borated materials: Boraflex (B, CH2, Si) ; Boral (B, Al, Na, Si); Borated Concrete; Borated Glass (Pyrex) (B, Si); Borated Plaster (B, S, Ca, Fe); Borated Polyethylene; Borated Stainless Steel (B, Fe, Cr, Ni); Borax (B, Na); Boron; Boron Carbide (B4C); ZrB_2
- Cadmium
- Copper
- Depleted Uranium
- Dysprosium Alloy (Dy, Ti)
- Europium
- Gadolinium Materials: Gadolinide Alloy (Gd, Ni, Cr, Mo), Gadolinium

- Graphite
- Hafnium
- Iron
- Lead
- Poly materials: Boraflex (B, CH_2, Si), Borated Polyethylene, PVC (CH_2, Cl), Polyethylene, Polystyrene (C, H)
- Rhenium
- Rhodium
- Samarium
- Silicon materials: Borated Glass (Pyrex) (B, Si), Silicon Dioxide
- Steel: Borated Stainless Steel (B, Fe, Cr, Ni), Carbon Steel, Stainless Steel (Fe, Cr, Ni)
- Thorium
- Vermiculite (H, C, N, O)
- Zirconium materials : Zircaloy (Zr, Fe, Sn, Cr), ZrB_2

The soluble neutron absorbing materials are:

- Boron
- Cadmium
- Fission Products[2]: Cesium, Europium, Rhodium, Samarium
- Gadolinium

Concentration (g/l)*

Concentrations of soluble neutron absorbing materials are given and refer to the amount of absorber material in the solution.

11.7. Separation Material

Material that geometrically separates fuel units and/or fuel assemblies (see item below). Typically, the materials are inserted into the experimental configuration specifically to study penetration of neutrons through them. When separation material is not present in an experimental configuration, this is indicated by "None."

The separation materials are:

- Air
- Aluminum materials: Aluminum, Boral (B, Al, Na, Si)
- Beryllium materials: Beryllium, Beryllium Oxide

[2] If Fission Products are involved in the experiment they are always entered as absorbers.

- Boron materials: Boraflex (B, CH2, Si), Boral (B, Al, Na, Si), Borated Concrete, Borated Glass (Pyrex) (B, Si), Borated Plastic Foam (B, C, H, O), Borated Polyethylene, Borated Stainless Steel (B, Fe, Cr, Ni), Foamglass (B, Si, Na, O)
- Cadmium
- Celotex (C, H, O)
- Chromium
- Concrete
- Copper
- Depleted Uranium
- Gadolinium materials: Gadolinide Alloy (Gd, Ni, Cr, Mo), Gadolinium
- Graphite
- Iron
- Lead
- Magnesium Oxide
- Molybdenum
- Nb-Zr
- Nickel
- None
- Plywood (C, H, O)
- Poly materials: Borated Polyethylene, Polyethylene, Polystyrene (C, H)
- Silicon Dioxide
- Steel materials: Borated Stainless Steel (B, Fe, Cr, Ni), Carbon Steel, Stainless Steel (Fe, Cr, Ni)
- Tantalum
- Titanium
- Tungsten
- Vanadium
- Water (Light Water)
- Zircaloy materials: Nb-Zr , Zircaloy (Zr, Fe, Sn, Cr), Zirconium

The absorbing separation materials are also entered as “Neutron absorbing material” (See Section 9.6).

11.8. Geometry

Major geometry details are given for benchmark configurations provided in Section 3.

If several benchmark models are available in Section 3, the geometry details for simplified model are provided in DICE.

The "Core geometry" and "Description for Complex/Mixed Geometry" are common to all the experiments within an evaluation. The data or search parameters "Fuel unit geometry," "Number of fissile units," "Pitch type," and "Pitch size (cm)" are provided for each experiment within an evaluation unless not applicable to the experimental configuration.

Core geometry

Basic characteristics of the core geometry that indicates whether the core is simple or complex. The core geometries are:

- Array: Assemblies, Fuel Units
- Infinite Media: Heterogeneous; Homogeneous
- Single Fuel Unit.

Fuel unit or Fuel unit geometry

Geometry of the elementary fuel unit. "Fuel unit" appears only as parameters to be selected on the Search window; "Fuel unit geometry" appears only on the Result window.

The basic fuel units are:

- Foil[3]
- Intersecting Pipes
- Micro-spheres (contained in): Spherical Pebbles
- Mixed/Complex Geometries
- Pellet
- Plate(s)[4]: Annular Plate(s), Curved Plate(s), Cylindrical Plate(s), Rectangular Plate(s)
- Rod(s): Annular Rod(s), Cylindrical Rod(s), Star Cross-Section Rod(s),
- Solid Body (Shape): Cuboid, Cylinder, Hemisphere, Hexagonal Block, Sphere, Annulus
- Tank(s): Annular Tank(s), Cylindrical Tank(s), Cylindrical Slab Tank(s), Nested Annular Tank(s), Nested Cylindrical Tank(s), Rectangular Tank(s), Rectangular Slab Tank(s), Spherical Tank(s)

Fuel Unit Description

Word description of fuel unit. This is provided for some configurations of Mixed/Complex Geometries.

Pitch type

Type of lattice geometry. The information in this section is available only for configurations with Mixed/Complex Geometry and/or Rods as Fuel Unit Geometry.

[3] Metal in the form of very thin sheets.

[4] A thin, flat piece of tough material.

The pitch types are: square and triangular.

Pitch size (cm)

Center-to-center distance of fuel units in the lattice. The information in this section is available only for the configurations with Mixed/Complex Geometry and/or Rods as Fuel Unit Geometry.

Number of fissile units

Number of fuel units in an assembly. The information in this section is available only if the core consists of assemblies or fuel units.

11.9. Fuel Area Composition

% Fissions*

The percentage of fissions by isotope over the core region, as indicated in the corresponding Spectra file (see the "Spectra" link at the top of the first page of each evaluation).

% Captures*

The percentage of capture by isotope over the core region, as indicated in the corresponding Spectra file (see the "Spectra" link at the top of the first page of each evaluation).

11.10. Energy and Spectra

These data are 3-group and 30-group spectra and absorption data available in the *ICSBEP Handbook* (see the "Spectra" link at the top of the first page of each evaluation to see the corresponding Spectra file). The details of calculations are reported in the section "Detailed Neutron Spectrum and Absorption Data (Criticality Alarm/ Shielding Benchmarks)" of the *Handbook*. Spectra files are currently not available for some evaluations, but are being continuously added as the files are calculated.

Energy of average neutron lethargy causing fission

The energy corresponding to the average neutron lethargy causing fission, *EALF (eV)*. The average neutron lethargy causing fission is defined for group calculations by:

$$\bar{u} = \frac{\sum_m \sum_g (\bar{u}_g \times \Sigma_{fg}^m \phi_g^m)}{\sum_m \sum_g \Sigma_{fg}^m \phi_g^m},$$

where m is the number of a physical zone inside the core; $\bar{u}_g$ is the midpoint of the g^{th} lethargy group, defined as the lethargy of a neutron with energy $\overline{E_g} = \sqrt{E_g E_{g-1}}$; Σ_{fg} is the group macroscopic fission cross section; and ϕ_g^m is the integral neutron flux in physical zone m and within lethargy group g.

Lethargy u of a neutron with energy E is defined as $ln\left(\frac{E_0}{E}\right)$, where E_0 indicates maximum neutron energy, in this case, 10 MeV. Therefore, $EALF = \frac{E_0}{e^{\bar{u}}}$.

Average fission group energy

The average neutron energy causing fission, *AFGE (eV)*:

$$AFGE = \frac{\sum_m \sum_g (E_g \times \Sigma_{fg}^m \phi_g^m)}{\sum_m \sum_g \Sigma_{fg}^m \phi_g^m},$$

where E_g is the midpoint of the g^{th} energy group, and other quantities are as previously defined.

Flux distribution or Fission distribution or Capture distribution

The percentage of the neutron flux, fissions, and captures, respectively, that occur in the fast (energy > 100keV), intermediate (0.625eV ≤ energy ≤ 100keV), and thermal (energy < 0.625eV) energy ranges.

Neutron balance

The percentage of fissions and captures by isotope over the core region. This option to specify a range of fission- or capture-fractions by isotope in the query of experiments is provided only in the Search window.

Neutron gas temperature

The neutron gas temperature (T_n) is limited to configurations with a thermal neutron spectrum. For group calculations, T_n is defined as:

$$T_n = \frac{\pi}{4}\left(\frac{\sum_m \sum_g \phi_g^m)}{\sum_m \sum_g \sigma_g \phi_g^m}\right)^2 T_0 \sigma_0^2,$$

where $\sigma_g = \sigma_0 \sqrt{\frac{E_0}{\bar{E}_g}}$, T_0 = 293.6 K, σ_0 is the cross section at E_0 = 0.0253 eV (v = 2200 m/s, T = 293.6 K), and ϕ_g is the neutron flux in the groups collapsed into the thermal group (E < 0.625 eV). Thus:

$$T_n = 9114.3\left(\frac{\sum_m\sum_g \phi_g^m)}{\sum_m\sum_g \frac{\phi_g^m}{\sqrt{E_g}}}\right)^2,$$

where $\overline{E}_g = \sqrt{E_g E_{g-1}}$.

Average fission neutrons per neutron absorbed in the core

The average number of fission neutrons produced per neutron absorbed in the core, ($\nu\Sigma_f/\Sigma_a$).

11.11. Benchmark k_{eff} and Uncertainty

If several benchmark models are available, the benchmark-model k_{eff} and uncertainty are usually provided for a simplified model.

***k*$_{eff}$**

The benchmark-model k_{eff} (as documented in Section 3.5) is the expected value of k_{eff} from a calculation using the benchmark model and from the measurement for an experiment with materials and geometry exactly as described by the benchmark model (as documented in Section 3).

***k*$_{eff}$ uncertainty (1σ)**

The uncertainty of k_{eff} of the benchmark model (as documented in Section 3.5) is the uncertainty of the adjustment of k_{eff} due to simplification of the model (from Section 3.1) combined with the uncertainty of k_{eff} due to uncertainties in experimental data (from Section 2) to obtain the final combined uncertainty.

11.12. Calculations

Calculated k_{eff} and Calculated k_{eff} uncertainty

k_{eff} and the uncertainty in k_{eff} calculated with various codes and cross-section data sets as tabulated in Section 4. The results are obtained for the benchmark-model specification(s) provided in Section 3. The specific code, cross section library, and benchmark-model label (as appropriate) are indicated for each calculation.

If several benchmark models are available, the calculated k_{eff} and uncertainty can be provided for any of them and corresponds to calculation label (see definition below).

The specific code, cross section library, and calculation label (as appropriate) are indicated for each calculation.

C/E*

Ratio of calculated k_{eff} to benchmark k_{eff} for the various codes and cross-section data sets as tabulated in Section 4 C/E values are provided for the benchmark-model k_{eff} values entered into DICE and the corresponding calculated k_{eff} values.

Code name*

The specific code(s) used to calculate the benchmark-model k_{eff} and k_{eff} uncertainty. This list includes all codes used in the *Handbook*. The version of the code is not indicated (for example, MCNP, KENO etc).

Library*

The specific cross-section library(ies) used for the benchmark-model k_{eff} and k_{eff} uncertainty calculations. This list includes all cross-section libraries currently employed by the codes used in the *Handbook.*

Calculation label*

Benchmark-model label, such as Simplified Model, Detailed Model, etc., as appropriate, or code name and version (for some configurations) is provided.

12. REFERENCES

1. "INTERNATIONAL HANDBOOK OF EVALUATED CRITICALITY SAFETY BENCHMARK EXPERIMENTS," NEA/NSC/DOC(95)03/I-VIII, OECD-NEA, September, 2009.
2. J. BLAIR BRIGGS ET. AL., "International Criticality Safety Benchmark Evaluation Project", *Nuclear Science and Engineering*, Vol. 145 Number 1, pages 1 – 10, September 2003.
3. V. A. F. DEAN., "The Benchmark Evaluation Process: From Experimental Data to Benchmark Model", *Nuclear Science and Engineering*, Vol. 145 Number 1, pages 20 – 38, September 2003.
4. A. NOURI ET. AL., "DICE: Database for the International Criticality Safety Benchmark Evaluation Project Handbook, Nuclear Science and Engineering, Vol. 145 Number 1, pages 11 – 19, September 2003.
5. T. T. IVANOVA et al., "Attempt of the Joint Analysis of the Entire Set of the HEU-SOL Type Experiments from the "International Handbook of Evaluated Criticality Safety Benchmark Experiments", Proceedings of the Seventh International Conference on Nuclear Criticality Safety, ICNC 2003, pages 283 - 288, October 2003.
6. SCALE: A Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation, ORNL/TM-2005/39, Version 6, Vols. I-III, Oak Ridge National Laboratory, Oak Ridge, Tennessee, January 2009. Available from Radiation Safety Information Computational Center at Oak Ridge National Laboratory as CCC-750.
7. B.T. Rearden, R.A. Lefebvre, A.B. Thompson, Y. Rugama, N. Soppera, and M. Bossant, "The VIBE Tool of SCALE - Validation, Interpretation and Bias Estimation", Accepted for publication NCSD2009.
8. Y. Rugama, N. Soppera, M. Bossant and B. Briggs, "DICE: Database for the International Criticality Safety Benchmark Evaluation Program Handbook" Proceedings of the Eighth International Conference on Nuclear Criticality Safety, ICNC 2007, Vol II pages 246 - 248, June 2007.

13. ACKNOWLEDGEMENTS

Specifications and data checking	J. Blair Briggs & A. Nichole Ellis (INL contact)
	Tatiana Ivanova & Nicolas Leclaire (IRSN contact)
	Ian Hill (NEA contact)
	Yolanda Rugama (former NEA contact)
	Ali Nouri (former NEA contact)
Database conception & programming	Pierre Nagel (now retired)
Java graphical user interface	Nicolas Soppera
	Manuel Bossant
	Francisco José Alvarez Sánchez
	Fabien Benoit
	David Cherasse
Parallel Axes Plot feature	IRSN
Data entry and checking	Mickaël Laurent
	Yuri Golovko
	Laetitia Ghander
	Paul Foster
	Leslie Foster
	Elena Bagdasarova
Data files providers	ORNL
	IPPE